

List of Significant Changes

Following are some of the significant changes that will be adopted for California if the Supplement Draft is approved for this chapter in its current form.

PART 4. HIGHWAY TRAFFIC SIGNALS

CHAPTER 4C. TRAFFIC CONTROL SIGNAL NEEDS STUDIES

This section replaces Traffic Manual Section 9-01 and completely re-arranges traffic signal warrants as follows:

- MUTCD “Warrant 1, Eight Hour Vehicular Volume” combines previous Traffic Manual “Warrant 1-Minimum Vehicle Volume,” Warrant 2-Interruption of Continuous Traffic,” and “Warrant 8-Combination of Warrants.”
- MUTCD “Warrant 2, Four-Hour Vehicular Volume” replaces Traffic Manual “Warrant 9-Four Hour Volume Warrant.”
- MUTCD “Warrant 3, Peak Hour” combines previous Traffic Manual “Warrant 10-Peak Hour Delay Warrant” and “Warrant 11, Peak Hour Volume Warrant.”
- MUTCD “Warrant 4, Pedestrian Volume” replaces Traffic Manual “Warrant 3-Minimum Pedestrian Volume”
- MUTCD “Warrant 5, School Crossing” replaces Traffic Manual “Warrant 4-School Areas.”
- MUTCD “Warrant 6, Coordinated Signal System” replaces Traffic Manual “Warrant 5-Progressive Movement.”
- MUTCD “Warrant 7, Crash Experience” replaces Traffic Manual “Warrant 6-Accident Experience.”
- MUTCD “Warrant 8, Roadway Network” replaces Traffic Manual “Warrant 7-Systems Warrant.”

Section 4C.02 Warrant 1, Eight Hour Vehicle Volume

The major traffic street critical speed criterion is changed from 64km/h to 70km/h for Rural locations.

Section 4C.06 Warrant 5, School Crossing

This section introduces the study of gaps in vehicular traffic streams to determine the need for traffic control signals.

CHAPTER 4D. TRAFFIC CONTROL SIGNAL FEATURES

NEW – This chapter expands on Traffic Manual Section 9-03 for Traffic Signal Design with application standards.

CHAPTER 4E. PEDESTRIAN CONTROL FEATURES

Section 4E.06 Accessible Pedestrian Signals

New- This section adds standards for audible sounds, verbal messages and vibro-tactile pedestrian devices.

Section 4E.07 Pedestrian Detector

New- This section adds standards for pedestrian detectors.

Section 4E.08 Accessible Pedestrian Signal Detector

New - This section adds standards for placing detectors and the operation of locator tones.

Section 4E.09 Pedestrian Interval and Signal Phases

New - This section adds standards for the operation of pedestrian signals.

CHAPTER 4F. TRAFFIC CONTROL SIGNALS FOR EMERGENCY VEHICLE ACCESS

New- This chapter adds standards for emergency-vehicle traffic control signals.

CHAPTER 4G. TRAFFIC CONTROL SIGNALS FOR ONE-LANE, TWO-WAY FACILITIES

New- This chapter adds standards for traffic signals for one-lane, two-way facilities.

CHAPTER 4H. TRAFFIC CONTROL SIGNALS FOR FREEWAY ENTRANCE RAMPS

New - This chapter adds design standards for freeway entrance ramp control signals.

CHAPTER 4I. TRAFFIC CONTROL SIGNALS FOR MOVABLE BRIDGES

New - This chapter adds standards for the design of movable bridge signals and gates.

CHAPTER 4J. LANE-USE CONTROL SIGNALS

New - This chapter adds standards for the design of for lane-use control signals.

CHAPTER 4L. IN-ROADWAY LIGHTS

New - This chapter adds standards for in-roadway lights.

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BUSINESS, TRANSPORTATION AND HOUSING AGENCY
DEPARTMENT OF TRANSPORTATION

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PART 4

HIGHWAY TRAFFIC SIGNALS



PART 4. HIGHWAY TRAFFIC SIGNALS

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CHAPTER 4B. TRAFFIC CONTROL SIGNALS – GENERAL

Section 4B.02 Basis of Installation or Removal of Traffic Control Signals

The following is added to this section:

Standard:

Once a traffic signal at an intersection or pedestrian crossing has been energized, it shall not be turned off unless arrangements have been made for temporary control by traffic officers, temporary stop signs or an approved portable signal.

Section 4B.05 Adequate Roadway Capacity

The following is added to this section:

Support:

When the vehicular volume on a two-lane State highway is large enough to warrant traffic signals, usually there will be considerable congestion after the signals are installed unless the State highway is widened to four lanes at the intersection. Sometimes, it is also necessary to widen the intersecting road.

Guidance:

Where possible, the highway approaches and local road approaches should be widened to two lanes for through traffic, for a minimum of 60 m (200 ft) for traffic approaching the intersection and for a minimum of 100 m (330 ft) for traffic leaving the intersection. Additional widening for tapered sections should be provided at the ends of the added lanes. It may be necessary to prohibit parking in these areas and/or to provide left turn lanes. See Section C4B.04 for financing.

CHAPTER C4B. TRAFFIC CONTROL SIGNALS -GENERAL (CALIFORNIA ONLY SECTIONS)

Section C4B.01 Traffic Signal Development Procedures –Introduction

Support:

General requirements for the development of traffic signal, lighting and electrical systems projects are noted in the Project Development Procedures Manual. The cost of traffic signals on Federal Aid highway projects is eligible for federal participation under certain conditions.

Option:

The preparation of a Project Study Report may be required for major traffic signal lighting and/or electrical system projects for scoping and programming purposes. The Project Development Procedures Manual and the appropriate Program Advisor should be consulted to determine specific reporting requirements.

Section C4B.02 Project Report

Standard:

The District shall prepare a project report of the investigation of conditions at locations where a new traffic signal is to be installed, an existing traffic signal is to be modified or an existing traffic signal is to be removed. District Directors are authorized to approve project reports in accordance with the current departmental policies contained in the Project Development Procedures Manual. Three copies of the District-approved project report shall be forwarded to the Chief, State and Local Project Development. A project report shall be prepared whether the work is performed by the State or by others.

Guidance:

General requirements for project reports are noted in the Project Development Procedures Manual. A project report for the installation, modification (except for upgrading projects involving specific equipment) or removal of a traffic signal should include the following specific information:

1. Traffic Counts.

Both pedestrian and vehicular traffic counts should include the periods of the average day when the signals would appear to be needed most. The counts should be at least eight hours in duration, not necessarily consecutive, but including a.m. and p.m. peak hours.

Traffic counts for a new signal shall be shown on appropriate Traffic Signal Warrant Sheets and a Directional Traffic Count Sheet. See Figures C4C-1 through C4C-3.

Where pedestrian volumes are significant, show the volume on each crosswalk for the same periods as the vehicle count.

When estimated traffic volumes are used in establishing traffic signal warrants, they should be prepared on Form TS-10D. See Figure C4C-2.

2. Collision Diagram.

A collision diagram for the intersection covering the recent accident experience history. The diagram should cover a 3-year interval.

3. Condition Diagram.

A condition diagram showing existing roadway conditions. Any railroad grade crossing within 60 m (200 ft) of the intersection should be shown.

4. Improvement Diagram.

A diagram showing existing and proposed signals, phasing, channelization and other proposed improvements. This may be combined with 1, 2 and/or 3 on a single plan.

5. Estimate.

An estimate of the cost of the project (including State furnished materials) and the proposed method of financing.

6. Other Specialized Data When Appropriate:

- a. Classification of Vehicles. The classification is required when it is a significant factor in affecting intersection capacity.
- b. Critical Speed (85th percentile) of Approaching Vehicles. This is the speed at a point unaffected by existing controls.
- c. Time-Space Diagram. When the project involves a coordinated traffic signal system.

Section C4B.03 Submittals

Standard:

General requirements for the submittal of plans, specifications and estimates are noted in the Project Development Procedures Manual and the PS&E Guide. All electrical plans shall bear the following: "Note: This plan accurate for electrical work only."

Section C4B.04 Financing

Guidance:

Unless previously budgeted, the financing of a project should be considered only after receipt of the PS&E Report and cooperative agreements.

Support:

Normally, the costs of a new traffic signal or the modification of a signal or signal system are to be shared with a local agency.

Option:

In situations where a new traffic signal or a modification to an existing traffic signal or traffic signal system is urgently needed to improve safety or traffic flow on the State highway and the local agencies are unable to finance their prorated share of the cost, the State may accept a lesser participation, or even no participation, by the local authorities.

Standard:

The definition of "urgently needed" shall be made by the District Director.

The cost of small projects such as modifications to existing traffic signals (detectors, signal heads, mast arms, etc.) where the prorated share of the local agency is \$3,000 or less, shall be at 100% State expense.

Section C4B.05 Design Cost

Standard:

The following criteria shall apply in determining the amount of participation in the design cost by the State and a local agency:

- a Where the State prepares plans for the installation or modification of a traffic signal or a traffic signal system on a State highway, the design costs should be shared with the local agency. Where the local agency is to prepare**

- the plans, the State may participate in the design costs. Participation should be the same as construction cost participation and be covered by a cooperative agreement.
- b Estimated design costs should be determined on the basis of an agreed fixed percentage of the total project costs. The fixed percentage should be based on historical design costs for projects in the price range concerned.
 - c Where the State is requested by a local agency to prepare plans and specifications for a traffic signal project that does not involve State participation in the construction costs, the design costs shall be borne entirely by the local agency or others. The State may, however, assume the design engineering costs and the construction engineering costs, where the local agency agrees to pay all of the construction costs for a warranted project and where all of the costs would normally be shared on a prorated basis.

Section C4B.06 Construction Costs - Conventional Highways

Standard:

The following criteria shall apply in determining the amount of the construction costs by the State and local agency for a traffic signal, safety lighting, and channelization or widening project on conventional State highways.

Channelization and/or Widening Costs. On cooperatively financed projects, the channelization and/or widening costs shall be shared as follows:

1. Channelization on and/or widening of the State highway shall be at 100% State expense.
2. Channelization on and/or widening of the local street shall be at 100% local agency expense.
3. Where the local agency's portion of the channelization or widening is a minor part of the channelization or widening being constructed by the State and the local agency's share of the work amounts to \$3,000, or less, the State may assume the entire cost of the channelization or widening.

Channelization and/or widening required, as a part of the conditions of a permit by a private party shall be at 100% expense of the private party.

In Cases A, B, and D listed below, the costs of constructing the electrical facilities are to be shared by the State and local agencies. The costs shall be shared on a prorated basis in the same ratio as the number of legs in the intersection under each agency's jurisdiction bears to the total number of legs.

Case A. Installation or Modification of a Traffic Signal and/or Safety Lighting at an Existing Intersection. When a traffic signal and/or safety lighting is to be installed or modified at the intersection of a State highway and a local

road, local agency participation in the installation or modification costs shall be sought.

- Case B. Existing Driveways at Existing Signalized Intersections.** A private driveway that constitutes a leg at an existing signalized intersection should be treated as follows:
1. If the driveway does not generate appreciable traffic, no control is required.
 2. If the driveway serves an area that generates sufficient traffic to constitute a problem, it should be controlled. One example of control is the use of a red flashing beacon and/or a RIGHT TURN ONLY (CA Code R41) sign to control egress from the private driveway. Another would be to provide signal indications for the private driveway.
 3. Costs shall be as in Case D.
- Case C. A New Road or Driveway at an Existing Signalized Intersection.** Where a new road or driveway is to be constructed to enter an existing "T" intersection, the cost of necessary right-of-way, traffic signal and/or safety lighting shall be at 100% local agency or permittee expense. The cost shall include the signal faces and detectors for the new approach and signal faces and detectors for left turns into the new approach and channelization, if necessary.
- Case D. Installation of a Traffic Signal and/or Safety Lighting at an existing intersection with a Driveway.** Where a traffic signal and/or safety lighting is to be installed at an existing intersection serving an area which generates sufficient traffic to constitute a problem that includes a private driveway as the fourth approach, the cost of signal and lighting equipment for the driveway approach shall be included in the cost of the entire installation.
- Where one or more legs of the intersection are under the jurisdiction of a local agency, the construction costs shall be shared with the local agency. The cost of the driveway leg shall be included with the local agency's share. It shall be the responsibility of the local agency to obtain the right-of-way, right-of-entry or easement necessary to install and maintain the signal equipment to be located on private property.
- Case E. Reconstruction of a Conventional State Highway.** When it is necessary to widen or reconstruct a State highway, the reconstruction and relocation of traffic control devices and safety lighting systems, shall be at 100% State expense. Local participation for purposes of expediting a project should be accepted. Additional traffic control devices installed in

connection with reconstruction of a conventional highway are to be treated as in Case A.

- Case F. Relocation of a Conventional State Highway.** When an existing State highway is relocated, the State will install warranted traffic control devices and safety lighting at State expense. Local participation will not be required. If, however, a local authority wishes to participate in a project in order to expedite it, local participation should be accepted.
- Case G. Installation of a Traffic Signal and/or Safety Lighting at a Private Driveway or Privately Owned Street.** The cost of a new traffic signal and/or safety lighting installed at a private driveway or privately owned street (i.e., not under the jurisdiction of a city or county) shall be entirely at the expense of the property owner or developer.

The permittee shall grant the State access rights to the private property at any time for the purpose of maintaining or timing the signal and lighting.

Upon installation, all rights, title and interest in the traffic signal equipment shall be granted to the State by the permittee. In the event that the State finds it advisable for the signals to be removed, the State will remove and salvage the equipment.

- Case H. Reconstruction of Existing Facilities.** When affected by State highway construction, existing street lighting, police and fire alarm systems, and similar systems owned by a city, county or publicly owned service district shall be relocated at the sole expense of the owner, unless prior rights can be established.
- Case I. School Traffic Signals and Flashing Beacons.** Where traffic signals and/or flashing beacons are justified only by the School Area Traffic Signal Warrant on a State highway, the installation shall be at 100% State expense. When any other warrant is met also, the cost is shared in the usual manner.

Section C4B.07 Construction Costs – Freeways

Standard:

The installation of electrical work and channelization at an intersection of a freeway ramp and a local road shall be at 100% State expense if such improvements are warranted at the time the freeway is to be opened to traffic, or if they are estimated to be warranted within five years after the date the freeway is opened to traffic.

Support:

It may be difficult to accurately predict the traffic pattern at interchanges at the time of the freeway design. Therefore, the need for signals at the ramp connections to local roads cannot always be anticipated.

Standard:

If within five years after the date of completion of the freeway, the interchange does not operate in the manner intended, and signal warrants are met, it shall be the policy to provide signals, lighting, channelization or roadway widening as necessary to facilitate the flow of traffic through the interchange. This work is to be done entirely at State expense in the same manner as it would have been done had it been planned in the original freeway project. This includes widening of roadway approaches to proposed signalized ramp intersections in accordance with present design practice entirely at State expense. Approval by local agencies should be obtained for changes to roads under their jurisdiction.

After the five-year period, the cost of installation shall be financed in the same manner as for existing intersections.

Option:

In lieu of treating each ramp intersection individually and sharing the costs on the basis of the number of legs under each jurisdiction, the concept of the overall facility as described in the Maintenance Manual may be used.

Standard:

Frontage roads or portions of frontage roads, which serve as connections between ramps to or from the freeway and existing public roads and which are retained under State jurisdiction, shall be considered as freeway ramps and electrical work at the intersections shall be financed as described above.

Any time the interchange is revised by adding or relocating ramps, it is considered a new interchange and the cost of signals at the ramp terminals and/or the connection to the local road shall be at 100% State expense.

Section C4B.08 Roadway Improvements by Local Agencies

Standard:

Any new connection of a local street to a State highway, including any electrical work, widening and/or channelization required within the State highway right of way, shall be at 100% local agency expense.

At existing intersections any relocation or improvement of electrical facilities due to widening and/or channelization of the local street shall be at 100% local agency expense.

Section C4B.09 Cooperative Agreements

Support:

When a local agency participates in the various project costs, a cooperative agreement is required.

Standard:

Each agreement shall include a statement of ownership, maintenance and operation.

Support:

Preapproved agreement forms and procedure details are available.

Section C4B.10 Engineering Services for Local Agencies

Standard:

Contracts with local agencies for the State to provide traffic signal control system engineering services shall include a clause relating to "Legal Relationships and Responsibilities".

Support:

Preapproved wording is available.

Section C4B.11 Salvaged Electrical Equipment

Support:

A construction project sometimes includes the removal of traffic signal, lighting or other electrical equipment that is not to be reused on the particular project.

Guidance:

The determination as to whether particular electrical equipment is salvable should be made at the District level. The determination as to whether or not to salvage existing equipment should be made on the basis of the economic benefit to the State and on the conservation of energy and/or materials that would result from salvaging and/or

reinstallation. Equipment should be salvaged if it falls within one of the following categories:

1. It is an item for which there is a foreseeable use.
2. It is part of an electrical installation owned jointly with another agency and the other agency has requested the salvaged equipment.
3. It is usable in some other District.
4. It can be immediately disposed of by other means.

Standard:

All electrical equipment removed and determined not to be salvable shall become the property of the contractor.

Equipment determined to be salvable shall be disposed of as follows:

1. **If the electrical installation is jointly owned by the State and one or more local agencies, each of the owners shall share in the salvage value. The local agencies shall be given first choice in obtaining the salvaged equipment. The agency obtaining the salvaged equipment shall reimburse the other agency in accordance with the proportionate ownership.**
2. **Where the State or local agency is replacing existing electrical equipment without the other agency participating in the cost of the new equipment, the salvaged equipment shall belong to the party or parties who bore the cost of the new equipment unless otherwise specified in an agreement or encroachment permit.**

The salvage value shall be determined at the District level during preparation of the preliminary report.

Guidance:

The salvage value should be such that if the equipment were taken into State storage it could be used economically for maintenance or as State-furnished material on contracts. The estimated salvage value should make the equipment more attractive to local agencies than the money representing the other partner's share of the salvage value. Wire and wiring supplies such as conduit, junction boxes, and connectors, and other materials should be considered as a lot at no value, or in any case, not more than the nominal sum of \$1.

Support:

Often, salvaged electrical equipment is available for use on new installations; in many cases this will result in considerable savings.

Section C4B.12 Encroachment Permits

Support:

Encroachment permits are required for a local agency or a private party to install or modify traffic signals and street lighting on a State highway.

Guidance:

Plans and Specifications prepared by Permittees should conform to State Standard Specifications, Standard Plans and be submitted to the District for review and approval.

Standard:

In each case, a statement of ownership, maintenance and operation shall be included in the permit.

Support:

A Permit Engineering Evaluation Report (PEER) may be prepared in lieu of a project report for all projects estimated to cost \$1,000,000 or less, as part of the encroachment permit review process. Instructions for PEER's are found in the Project Development Procedures Manual and the Encroachment Permits Manual.

Standard:

All projects financed, in whole or in part, from retail transactions and use taxes and projects costing more than \$1,000,000 requires a cooperative agreement.

Section C4B.13 Modifications of Existing Signals

Guidance:

Where existing signals are to be modified, construction plans should include a separate plan of the existing system as well as a plan showing the modifications.

Option:

It may also be necessary to include a tabulation on the plan showing such appurtenances as backplates and special signal faces that may be difficult to discern on a complicated plan.

Guidance:

The design of any signal modification project should include adequate consideration for keeping the existing signals in operation while the modification work is being done.

Section C4B.14 Signals on Poles Owned by Others

Option:

Traffic signal equipment may be attached to poles owned by utility companies or other agencies when it is desired to keep the number of poles at an intersection to a minimum.

Guidance:

In such cases, the Agency should enter into an agreement with the owner of the pole. The agreement should be written to hold the owner of the pole free of liability relative to operation of the traffic signal or damage to the pole and to make the State or Local Transportation Agency responsible for moving the equipment in the event the pole is removed or relocated.

CHAPTER 4C. TRAFFIC CONTROL SIGNAL NEEDS STUDIES

Section 4C.01 Studies and Factors for Justifying Traffic Control Signals

The following is added to this section:

Standard:

Delay, congestion, approach conditions, driver confusion, future land use or other evidence of the need for right of way assignment beyond that which could be provided by stop sign shall be demonstrated.

Support:

Figures C4C –1 and C4C –2 are examples of warrant sheets. Warrant Sheet C4C – 2 should be used only for new intersections or other locations where it is not reasonable to count actual traffic volumes.

Section 4C.06 Warrant 5, School Crossing

The following is added to this section:

Option:

Flashing beacons at school crosswalks may be installed on State highways in accordance with Sections 21372 and 21373 of the California Vehicle Code.

The following alternative criterion may be used for determining if a school crossing traffic signal is justified under this warrant:

1. When other warrants in this Chapter are met AND
2. No other controlled crossing is located within 180 m (600 ft) AND;
3. Urban Areas - 500 vehicles and 100 school pedestrians for each of any two hours (not necessarily consecutive) daily while students are crossing to or from school; or 500 vehicles for each of any two hours daily while students are crossing to or from school and a total of 500 school pedestrians during the entire day. OR
4. Rural Areas - 350 vehicles and 70 school pedestrians for each of any two hours (not necessarily consecutive) daily while students are crossing to or from school; or 350 vehicles for each of any two hours (not necessarily consecutive) daily while students are crossing to or from school and minimum total of 350 school pedestrians during the entire day.

Guidance:

When the critical (85th percentile) approach speed exceeds 55 km/h (35 mph) or the sight distance to the intersection is less than the required stopping sight distance, rural criteria should be applied.

Standard:

The design of school crossing traffic signals shall include the following considerations:

- 1. The signals shall be designed for full-time operation.**
- 2. Pedestrian signal faces of the International Symbol type shall be installed at all marked crosswalks at signalized intersections along the "Suggested Route to School."**
- 3. Non-intersection school pedestrian crosswalk locations may be signalized when justified.**
- 4. If an intersection is signalized under this guideline for school pedestrians, the entire intersection shall be signalized.**
- 5. School area traffic signals shall be traffic actuated type with push buttons or other detectors for pedestrians.**

CHAPTER C4C. TRAFFIC CONTROL SIGNAL WARRANTS (CALIFORNIA ONLY SECTIONS)

Section C4C.01 Function of School Crossing Traffic Signals

Support:

A traffic signal assigns intersection right-of-way and promotes the orderly movement of pedestrians and vehicles. However, improper signal controls sometimes lead to intentional violations, unnecessary delays and traffic diversion to less desirable routes.

Section C4C.02 Criterion for School Crossing Traffic Signals

Standard:

- 1. The signal shall be designed for full-time operation.**
- 2. Pedestrian signal faces of the International Symbol type shall be installed at all marked crosswalks at signalized intersections along the “Suggested Route to School.”**
- 3. If an intersection is signalized under this guideline for school pedestrians, the entire intersection shall be signalized.**
- 4. School area traffic signals shall be traffic actuated type with push buttons or other detectors for pedestrians.**

Option:

Non-intersection school pedestrian crosswalk locations may be signalized when justified.

Section C4C.03 Bicycle Signal Warrant

Guidance:

A bicycle signal should be considered for use only when the volume and collision or volume and geometric warrants have been met:

- Volume*, When $W = B \times V$ and $W \geq 50,000$ and $B \geq 50$.
Where: W is the volume warrant. B is the number of bicycles at the peak hour entering the intersection. V is the number of vehicles at the peak hour entering the intersection. B and V shall use the same peak hour.
- Collision*, When 2 or more bicycle/vehicle collisions of types susceptible to correction by a bicycle signal have occurred over a 12-month period and the responsible public works official determines that a bicycle signal will reduce the number of collisions.

3. *Geometric*, (a) Where a separate bicycle/ multi use path intersects a roadway. (b) At other locations to facilitate a bicycle movement that is not permitted for a motor vehicle.

Figure C4C-1. Traffic Signal Warrants Worksheet (Sheet 1 of 4)

DIST _____	CO _____	RTE _____	KPM _____	CALC _____ DATE _____	
				CHK _____ DATE _____	
Major St: _____				Critical Approach Speed _____ km/h	
Minor St: _____				Critical Approach Speed _____ km/h	
Critical speed of major street traffic > 70 km/h (45 mph)..... <input type="checkbox"/>				}	RURAL (R)
In built up area of isolated community of < 10,000 population..... <input type="checkbox"/>					
<input type="checkbox"/> URBAN (U)					

EIGHT HOUR VEHICULAR WARRANT 1

Condition A - Minimum Vehicle Volume

100% SATISFIED YES ☐ NO ☐

80% SATISFIED YES ☐ NO ☐

		MINIMUM REQUIREMENTS (80% SHOWN IN BRACKETS)											
		U	R	U	R								
APPROACH LANES		1		2 or More									
Both Approaches Major Street		500 (400)	350 (280)	600 (480)	420 (336)								
Highest Approaches Minor Street		150 (120)	105 (84)	200 (160)	140 (112)								

Condition B - Interruption of Continuous Traffic

100% SATISFIED YES ☐ NO ☐

80% SATISFIED YES ☐ NO ☐

		MINIMUM REQUIREMENTS (80% SHOWN IN BRACKETS)											
		U	R	U	R								
APPROACH LANES		1		2 or More									
Both Approaches Major Street		750 (600)	525 (420)	900 (720)	630 (504)								
Highest Approaches Minor Street		75 (60)	53 (42)	100 (80)	70 (56)								

Combination of Conditions A & B

SATISFIED YES ☐ NO ☐

REQUIREMENT	WARRANT	✓	FULFILLED
TWO WARRANTS SATISFIED 80%	1. MINIMUM VEHICULAR VOLUME		Yes <input type="checkbox"/> No <input type="checkbox"/>
	2. INTERRUPTION OF CONTINUOUS TRAFFIC		

Figure C4C-1. Traffic Signal Warrants Worksheet (Sheet 2 of 4)

WARRANT 2 - Four Hour Vehicular Volume

SATISFIED* YES ☐ NO ☐

Record hourly vehicular volumes for four hours.

APPROACH LANES	One	2 or More				Hour
Both Approaches - Major Street						
Highest Approaches - Minor Street						

*All plotted points fall above the curves in MUTCD Figure 4C-1 or 4C-2.

Yes ☐ No ☐

WARRANT 3 - Peak Hour (All Parts Must Be Satisfied)

SATISFIED YES ☐ NO ☐

1. The total delay experienced for traffic on one minor street approach controlled by a STOP sign equals or exceeds four vehicle-hours for a one-lane approach and five vehicle-hours for a two-lane approach; AND
2. The volume on the same minor street approach equals or exceeds 100 vph for one moving lane of traffic or 150 vph for two moving lanes; AND
3. The total entering volume serviced during the hour equals or exceeds 800 vph for intersections with four or more approaches or 650 vph for intersections with three approaches.

Yes ☐ No ☐

Yes ☐ No ☐

Yes ☐ No ☐

SATISFIED* YES ☐ NO ☐

APPROACH LANES	One	2 or More				Hour
Both Approaches - Major Street						
Highest Approaches - Minor Street						

*Refer to MUTCD Figure 4C-1 (Urban Areas) or Figure 4C-2 (Rural Areas) to determine if this warrant is satisfied.

WARRANT 4 - Pedestrian Volume

100% SATISFIED YES ☐ NO ☐

Hours - - ->				
Pedestrian Volume				
Adequate Crossing Gaps				

Any hour > 100
AND 4 hours > 190
AND < 60 gap/hr

Yes ☐ No ☐

Yes ☐ No ☐

Yes ☐ No ☐

AND, The distance to the nearest traffic signal along the major street is greater than 90m (300 ft)

----- Yes ☐ No ☐

AND, The new traffic signal will not seriously disrupt progressive traffic flow in the major street.

----- Yes ☐ No ☐

Figure C4C-1. Traffic Signal Warrants Worksheet (Sheet 3 of 4)

DIST _____	CO _____	RTE _____	KPM _____	CALC _____	DATE _____
				CHK _____	DATE _____
Major St: _____				Critical Approach Speed _____ km/h	
Minor St: _____				Critical Approach Speed _____ km/h	
Critical speed of major street > 70 km/h (45 mph).....				<input type="checkbox"/>	} RURAL (R)
In built up area of isolated community of < 10,000 population.....				<input type="checkbox"/>	
				<input type="checkbox"/>	
				URBAN (U)	

FLASHING YELLOW SCHOOL SIGNALS **SATISFIED YES ☐ NO ☐**
(All Parts Must Be Satisfied)

		MINIMUM REQUIREMENTS				
		U	R			
Part A						
Vehicle Volume	Each of 2 Hours	200	140			} SATISFIED YES <input type="checkbox"/> NO <input type="checkbox"/>
School Age Pedestrians Crossing Street	Each of 2 Hours	40	40			

AND

Part B

Critical Approach Speed Exceeds 55 km/h (35 mph) **SATISFIED YES ☐ NO ☐**

AND

Part C

Is Nearest Controlled Crossing More Than 180 m (600 ft) away? **SATISFIED YES ☐ NO ☐**

SCHOOL AREA TRAFFIC SIGNAL **SATISFIED YES ☐ NO ☐**
(All Parts Must Be Satisfied)

Part A
Gap/Minutes and # of Children

Each of Two Hours - - ->			
Gaps vs Minutes	Minutes Children Using Crossing		
	Number of Adequate Gaps		
School Age Pedestrians Crossing Street			

Gaps < Minutes **SATISFIED YES ☐ NO ☐**

Children > 20 **SATISFIED YES ☐ NO ☐**

Part B
Distance to Nearest Controlled Crossing

Is Nearest Controlled Crossing More Than 180 m (600 ft) away? **SATISFIED YES ☐ NO ☐**

Figure C4C-1. Traffic Signal Warrants Worksheet (Sheet 4 of 4)**WARRANT 6 - Coordinated Signal System****SATISFIED** YES ☐ NO ☐

MINIMUM REQUIREMENTS	DISTANCE TO NEAREST SIGNAL	FULFILLED
> 300 m (1000 ft)	N _____ m, S _____ m, E _____ m, W _____ m	Yes <input type="checkbox"/> No <input type="checkbox"/>
On one way isolated streets or streets with one way traffic significance and adjacent signals are so far apart that necessary platooning and speed control would be lost.		<input type="checkbox"/> <input type="checkbox"/>
On 2-way streets where adjacent signals do not provide necessary platooning and speed control proposed signals could constitute a progressive signal system.		

WARRANT 7 - Crash Warrant**SATISFIED** YES ☐ NO ☐

REQUIREMENTS	WARRANT	✓	FULFILLED
One Warrant Satisfied 80%	Warrant 1 - Minimum Vehicular Volume	<input type="checkbox"/>	Yes <input type="checkbox"/> No <input type="checkbox"/>
	OR Warrant 2 - Interruption of Continuous Traffic	<input type="checkbox"/>	
Signal Will Not Seriously Disrupt Progressive Traffic Flow			<input type="checkbox"/> <input type="checkbox"/>
Adequate Trial of Less Restrictive Remedies Has Failed to Reduce Accident Frequency			<input type="checkbox"/> <input type="checkbox"/>
Acc. Within a 12 Month Period Susceptible for Corr. & Involving Injury or ≥ \$500 Damage			<input type="checkbox"/> <input type="checkbox"/>
MINIMUM REQUIREMENTS	NUMBER OF ACCIDENTS		
5 or More			

WARRANT 8 - Roadway Network**SATISFIED** YES ☐ NO ☐

MINIMUM VOLUME REQUIREMENTS	ENTERING VOLUMES - ALL APPROACHES	✓	FULFILLED
1000 Veh/Hr	During Typical Weekday Peak Hour _____ Veh/Hr	<input type="checkbox"/>	Yes <input type="checkbox"/> No <input type="checkbox"/>
	OR During Each of Any 5 Hrs. of a Sat. and/or Sun _____ Veh/Hr	<input type="checkbox"/>	
CHARACTERISTICS OF MAJOR ROUTES		MAJOR ST.	MINOR ST.
Hwy. System Serving as Principal Network for Through Traffic			
Rural or Suburban Highway Outside Of, Entering, or Traversing a City			
Appears as Major Route on an Official Plan			
Any Major Route Characteristics Met, Both Streets			<input type="checkbox"/> <input type="checkbox"/>

The satisfaction of a warrant is not necessarily justification for a signal. Delay, congestion, confusion or other evidence of the need for right-of-way assignment must be shown.

**Figure C4C-2. Traffic Signal Warrants Worksheet
(Average Traffic Estimate Form)**

(Based on Estimated Average Daily Traffic - See Note)

URBAN..... RURAL.....		Minimum Requirements EADT			
1A - Minimum Vehicular Traffic		Vehicles Per Day on Major Street (Total of Both Approaches)		Vehicles Per Day on Higher-Volume Minor Street Approach (One Direction Only)	
Satisfied _____ Not Satisfied _____					
Number of lanes for moving traffic on each approach		Urban	Rural	Urban	Rural
Major Street	Minor Street				
1.....	1.....	8,000	5,600	2,400	1,680
2 or More.....	1.....	9,600	6,720	2,400	1,680
2 or More.....	2 or More.....	9,600	6,720	3,200	2,240
1.....	2 or More.....	8,000	5,600	3,200	2,240
1B - Interruption of Continuous Traffic		Vehicles Per Day on Major Street (Total of Both Approaches)		Vehicles Per Day on Higher-Volume Minor Street Approach (One Direction Only)	
Satisfied _____ Not Satisfied _____					
Number of lanes for moving traffic on each approach		Urban	Rural	Urban	Rural
Major Street	Minor Street				
1.....	1.....	12,000	8,400	1,200	850
2 or More.....	1.....	14,400	10,080	1,200	850
2 or More.....	2 or More.....	14,400	10,080	1,600	1,120
1.....	2 or More.....	12,000	8,400	1,600	1,120
1A&B - Combinations		2 Warrants		2 Warrants	
Satisfied _____ Not Satisfied _____					
No one warrant satisfied, but following warrants fulfilled 80% or more..... 1 2					

Note: To be used only for NEW INTERSECTIONS or other locations where it is not reasonable to count actual traffic volumes.

CHAPTER 4D. TRAFFIC CONTROL SIGNAL FEATURES

Section 4D.02 Responsibility for Operation and Maintenance

The following is added to this section:

Support:

The California Department of Transportation is responsible for the operation of all State highway traffic signals, regardless of whether the signal is maintained by the State or by others.

Standard:

State highway traffic signals shall include, but are not necessarily limited to, all signals on a State highway and at ramp connections to local streets.

Maintenance and operation of highway traffic signals involving State Highways by an agency other than the California Department of Transportation shall require a jointly approved written agreement.

Section 4D.06 Application of Steady Signal Indications for Left Turns

The following is added to this section:

Guidance:

Since separate signal phases for protected left turns will reduce the green time available for other phases, alternate means of handling left turn conflicts should be considered first.

The most likely possibilities are:

1. Prohibition of left turns. This can be done only if there are convenient alternate means of making the movement. Typical alternate means are:
 - a. A series of right and/or left turns around a block to permit getting to the desired destination; or
 - b. Making the left turn at an adjacent unsignalized intersection during gaps in the opposing through traffic.
2. Geometric changes to eliminate the left turn. An effective change would be a complete separation or a complete or partial "clover leaf" at grade. Any of these, while eliminating left turns, requires additional cost and right of way.

3. Provide protected-permissive or permissive-protected left turn operation. The protected left turn interval may be prohibited during certain periods of the day to allow only permissive intervals for left turn movement in order to increase the green time available for other phases. Refer to Section C4D.12 for the requirements of protected-permissive or permissive-protected left turn operation.

Protected left turn phases should be considered where such alternatives couldn't be utilized, and one or more of the following conditions exist:

1. Accidents - Five or more left turn accidents for a particular left turn movement during a recent 12-month period.
2. Delay - Left-turn delay of one or more vehicles, which were waiting at the beginning of the green interval and are still remaining in the left turn lane after at least 80% of the total number of cycles for one hour.
3. Volume - At new intersections where only estimated volumes are available, the following criteria may be used. For pretimed signal or a background-cycle-controlled actuated signal, a left turn volume of more than two vehicles per approach per cycle for a peak hour; or for a traffic-actuated signal, 50 or more left turning vehicles per hour in one direction with the product of the turning and conflicting through traffic during the peak hour of 100,00 or more.
4. Miscellaneous. Other factors that might be considered include but are not limited to: impaired sight distance due to horizontal or vertical curvature, or where there are a large percentage of buses and trucks.

Section 4D.07 Application of Steady Signal Indications for Right Turns

The following is added to this section:

Guidance:

A right-turn green arrow should be considered for use only when there is an exclusive right-turn lane or it is the only movement that traffic is permitted to make or when the right-turn volume exceeds 200 vehicles per hour.

Section 4D.10 Yellow Change and Red Clearance Intervals

The following is added to this section:

Support:

The purpose of the yellow signal indication is to warn traffic approaching the signal that the related green movement is ending or that a red indication will be exhibited immediately thereafter and traffic will be required to stop when the red signal is exhibited.

Guidance:

The length of the yellow change interval is dependent upon the speed of approaching traffic. See Table C4D-2 for suggested minimum yellow interval timing.

Option:

Red clearance intervals which follow yellow change intervals are not required, but may be considered where any of the following conditions exist:

1. Intersections that are wide, offset or contain unusual geometry; intersections where the visibility of conflicting traffic is blocked or limited;
2. Movements where the approach speeds are 90 km/h (55 mph) or more; or
3. Where it is desirable to help clear vehicles that recurrently become queued in the intersection where there are permissive left turns.

Guidance:

Red clearance intervals range from 0.01 to 2.0 seconds and should not exceed 6 seconds.

Section 4D.15 Size, Number, and Location of Signal Faces by Approach

The following is added to the first standard, second paragraph of this section:

F. For mast-arm mounted, span-wire mounted and signal bridge mounted indications

The following is added to this section:

Standard:

There shall be at least two signal faces for each controlled approach of an intersection including signalized left turn lanes.

Guidance:

Supplemental signal faces should be considered if any of the following conditions exist:

1. The area is rural.
2. The area is urban and the signal is the first one on a particular highway.

3. The roadway is striped for two or more approach lanes.
4. Where visibility of the signal is affected by alignment or obstructions.

Support:

On an undivided roadway, the signal faces for each through approach of an intersection are usually placed at the far right and far left corners.

Option:

The signal faces for two or more approaches may be combined on a single standard.

Support:

However, it is generally desirable to locate the signal faces on separate standards at curb returns. This practice will tend to maximize the visibility of the signal faces for the controlled approach while minimizing the visibility of the signal faces intended for the cross-street approach.

Guidance:

Separate standards should be considered whenever the curb return radius is greater than 3 m (10 ft).

The preferred locations for new installations of signal faces for fully-protected left turn movements at a typical intersection are on a mast arm of sufficient length to place one signal face as nearly as practical in line with the left turn lane and to place the second face on a standard at the far left corner.

Option:

Unusual roadway geometrics, wide medians, wide roadways, more than one left turn lane in the same direction or other factors may require the left turn signal face(s) to be mounted on standard(s) located in a median to satisfy visibility requirements.

A signal face, containing a circular green indication, may be located in a far median only when:

1. The signal phasing provides a protected left turn movement; or
2. The signal face is provided with some type of visibility control so that the indications are not visible to traffic in the left turn storage lane; or
3. It is not facing a left turn storage lane.

A signal face containing a circular green indication may be located in the near median where there is a left turn storage lane and there is no associated left turn phase.

Supplemental signal faces may be placed at a near side location or suspended from a mast arm.

Section 4D.19 Lateral Placement of Signal Supports and Cabinets

The following is added to this section:

Guidance:

Normally, controller cabinets should be located in accordance with the following:

1. It should not be vulnerable to traffic.
2. Traffic movements at the intersection should be visible from the controller timing position.
3. The doors of the cabinet should open away from the curb or traveled way.
4. It should be possible to park a maintenance truck close to the cabinet.
5. It should not be located in a drainage ditch, in an area which could be under water or where subjected to water from sprinklers.
6. It should not obstruct sidewalks, wheelchair ramps, or store entrances.
7. It should be placed so as not to obstruct pedestrian or driver visibility.

Support:

Refer to Figures C4D-2 through C4D-8 for typical signal layouts for various intersections.

Standard:

Upon requests, keys for the police panel on traffic signal controller cabinets shall be furnished to the California Highway Patrol offices or local enforcement agencies.

Section 4D.20 Temporary Traffic Control Signals

The following is added to this section:

Option:

Temporary signals for traffic control at the intersection of a State highway and a haul road, or to provide one-way traffic control through a construction zone, may be either the fixed or portable type. Such-signals are normally installed by a contractor and may require an Encroachment Permit.

Standard:

1. Requirements.

Each plan for temporary signals shall include the equipment details as well as the following operating requirements:

- a. **Shall meet all requirements of section 4D.20 of the MUTCD**

- b. Signal faces, detectors and control equipment is to be kept in good operating condition at all times.
- b. When not in use, portable signals are to be removed from the vicinity of the highway and fixed signals are to be placed in flashing operation with yellow indications for the highway and red indications for the haul road.
- d. Timing of the signals will be determined by the Agency having jurisdiction.
- e. A Signal Ahead (W3-3) sign (and flashing beacon, if required) is to be placed on each approach of the highway in advance of the signal.
- f. Haul road signals shall be operated using manual control or vehicle detectors. The operation shall provide a green indication to the haul road only if the contractor's equipment is approaching the crossing. The haul road green interval shall not exceed 10 seconds and the highway green interval shall not be less than 20 seconds, unless specific permission is given in writing. A 3-second, minimum, yellow change interval, and any required red clearance interval shall follow each green interval.
- g. One-way traffic control signals may utilize pretimed or traffic-actuated controller units,
- h. Or may be manually controlled. A 3-second, minimum, yellow change interval shall follow each green interval. An all-red clearance interval shall follow each yellow change interval. The all-red clearance interval shall permit a vehicle to travel the length of the one-way lane before a green indication is shown to opposing traffic.
- i. Failure to comply with any of the above or other specified conditions will be justification for revoking the permit.

2. Equipment Details.

Fixed temporary traffic signals shall be designed for 120-volt operation, while portable temporary signals may be battery operated. The vehicle signal faces shall be the standard 3-section type with no less than two separate signal faces for each approach, including the haul road approaches. The signal faces shall be mounted a minimum of 3 m (10 ft) above the roadway and directed so that the indications are readily seen by traffic. The signal faces for highway traffic shall be equipped with backplates.

For one-way lane control or where conditions require sets of signals to be coordinated, the sets may be interconnected by cable or radio so that they are operated from a single manual or automatic control. The control system shall be designed to prevent conflicting green indications.

CHAPTER C4D. TRAFFIC CONTROL SIGNAL FEATURES (CALIFORNIA ONLY SECTIONS)

Section C4D.01 Traffic Signal Design Introduction

Support:

The design of traffic signals by the California Department of Transportation (Caltrans) is based upon the following publications:

1. The MUTCD (FHWA) with this Supplement (Caltrans)
2. Standard Specifications (Caltrans)
3. Standard Plans (Caltrans)
4. Signal and Lighting Design Guide (Caltrans)
5. Ramp Meter Design Manual (Caltrans)
6. Highway Design Manual (Caltrans)

Additional references that can be used include:

1. Transportation and Traffic Engineering Handbook, Institute of Transportation Engineers (ITE)
2. Manual of Traffic Signal Design (ITE)
3. Traffic Control Systems Standards, National Electrical Manufacturers Association (NEMA)
4. Traffic Control Devices Handbook, Institute of Transportation Engineers (ITE)

Section C4D.02 Signal Plan Schedules

Guidance:

The traffic signal plans for the installation of a new signal or the major modification of an existing signal should include the following schedules:

1. Pole and Equipment Schedule.
A pole and equipment schedule shows the types of standards, mast arm lengths, types and mounting for vehicle and pedestrian signal faces, and other equipment. See Table C4D-6 and the Standard Plans.
2. Conductors and Conduit Schedule.
A conductor and conduit schedule shows the size of each conduit run, and the size, type and number of conductors or cables in each conduit run. See Table C4D-7.

Support:

Dimensions of conductors and conduit and data for determining conduit size are shown in Tables C4D-8 and C4D-9.

Section C4D.03 Vehicle Detectors

Support:

The proper operation of a traffic-actuated signal is dependent upon the appropriate type and proper placement of detectors. The types and applications of vehicle detectors currently used include the following:

1. Inductive Loop - The inductive loop detector, because of its presence feature, detects a standing vehicle as well as a moving one. The detection area is roughly that enclosed by the loop.
2. Magnetometer- The magnetometer detector detects a standing vehicle, as well as a moving one, and has a detection area up to 1 m (3.3 ft) in diameter over each sensing element.
3. Magnetic- The magnetic detector detects only vehicles moving in excess of 8 km/h (5 mph). One sensing element covers one or two traffic lanes.
4. Video Detection- Detects vehicles passing through the field of view of a CCTV camera or image sensor. They are useful during construction or other temporary situations when lanes change frequently in width and location as well as where the installation of conduit and detector loops is expensive or difficult. Care is necessary to avoid locations and conditions, which could obscure the detector's visibility such as extreme weather, sun glare and moving shadows.
5. Pressure Sensitive.

Standard:

No new pressure sensitive installations shall be made. Existing units shall be replaced with other types of detectors loop when:

- a. They require relocation;**
- b. The traffic signal is to be modified; or**
- c. The roadway is to be resurfaced.**

Support:

The normal installation of inductive loop and magnetometer detectors requires sound pavement if the detector is to operate reliably.

Guidance:

If the pavement on an approach in which these detectors are to be installed is cracked, the project should include resurfacing of the areas where the detectors and lead-in cables are to be placed.

Support:

Typical installation details for inductive loop and magnetometer detectors are shown on the Standard Plans. The longitudinal location (setback) of detectors relative to the limit line depends on the speed of traffic and the type of detector operation desired. See Table C4D-1 for suggested setback from Limitlines.

Section C4D.04 Bicycle Signals

Support:

A bicycle signal is an electrically powered traffic control device that may only be used in combination with an existing traffic signal. Bicycle signals shall direct bicyclists to take specific actions and may be used to improve an identified safety or operational problem involving bicycles.

Standard:

When bicycle traffic is controlled, only green, yellow and red lighted bicycle symbols, shall be used to implement bicycle movement at a signalized intersection. The application of bicycle signals shall be implemented only at locations that meet Department of Transportation Bicycle Signal Warrants. This will remain in effect until January 1, 2005.

A separate signal phase for bicycle movement shall be used.

Guidance:

Alternative means of handling conflicts between bicycles and motor vehicles should be considered first.

Two alternatives that to be considered are:

1. Striping to direct a bicyclist to a lane adjacent to a traffic lane such as a bike lane to left of a right-turn-only lane.
2. Redesigning the intersection to direct a bicyclist from an off-street path to a bicycle lane at a point removed from the signalized intersection.

A bicycle signal phase should be considered only after these and other less restrictive remedies have had an adequate trial with enforcement and with the result that the

collision frequency has not been reduced.

Section C4D.05 Bicycle Detectors

Option:

Bicycle detectors may be required at traffic-actuated signal installations.

Standard:

A Type D loop configuration shown on Standard Plan ES5B is effective for detecting bicycles and small motorcycles and shall be installed at the bicycle loop detector locations. Loop detectors shall not be placed within a pedestrian crosswalk or where it could conflict with pedestrian traffic.

Guidance:

The loop detector logo shown on Standard Plan A24C may be used to show a bicyclist where to stop in a bike lane or traffic lane to be detected. The logo should be applied to the pavement in the center of the Type D loop.

Support:

See Figure C4D-11 for suggested locations of bicycle detectors and the Standard Plans for typical bike lane pavement markings.

Section C4D.06 Selection of Traffic Signal Operation

Guidance:

A prime factor to be considered in selection of the type of traffic signal operation is adequacy. While it may be true that a sophisticated signal control will operate satisfactorily at any intersection, the intersection should not be provided with a type of control that is unnecessarily complex and expensive.

Support:

The type of traffic signal operation to be used is dependent upon the variations in traffic demand. The two general types of signal operation are pretimed and traffic-actuated. Traffic-actuated operation can be further classified as full-traffic-actuated or semi-traffic-actuated. With full-traffic-actuated operation, all traffic movements or phases are provided with detectors. In semi-traffic-actuated operation, certain phases (usually the coordinated phases) do not have detectors.

Guidance:

Pretimed and semi-traffic-actuated operation should be used in coordinated systems only. They should not be installed at isolated intersections (more than 1.6 km (1 mile) from the closest signalized intersection).

Where the distance between signalized intersections is 0.8 km (0.5 mile) or less, coordination of signals should be considered, including the preparation of a time-space diagram and an evaluation of the cost-effectiveness of coordination.

Discretion should be used with phasing at offset intersections as it may introduce operational problems, which should be recognized and avoided. The most critical of these problems is where one approach right-of-way is terminated while the opposing approach continues with a green indication.

Section C4D.07 Selection of Left-Turn Phasing

Support:

There are various methods to signalize left turn movements. See Figure C4D-1.

Guidance:

If the left turn volume is 300 or more vehicles per hour, or if delays to traffic at the intersection can be significantly reduced, consideration should be given to a two-lane left turn.

Section C4D.08 Dual Left

Support:

This method is most effective during free or isolated operation and is traffic-actuated. It is the most efficient means of providing protected left turn movements since the various phases and combinations of phases appear only on demand. A through movement is allowed to go with its associated left turn movement when there is no opposing left turn traffic.

Section C4D.09 Lead-Lag

Guidance:

This operation can be either pretimed or traffic-actuated. Normally, "Lead-Lag" phasing should be considered for coordinated signals when the offset timing determined by the system time-space diagram results in the arrival of the two directions of traffic at different times during a cycle. This will provide the most efficient progressive band.

Section C4D.10 Opposite or Opposing

Guidance:

Opposing operation should be used where the left turn volume per lane is very high in either direction and is about equal to or greater than the companion through movement. This method is especially useful when one of the through lanes must be used as an optional turning lane or where a separate left turn lane cannot be provided.

Section C4D.11 Three Phase Operation

Option:

Three-phase operation can be either pretimed or traffic-actuated.

Section C4D.12 Permissive Left-Turn Phasing

Guidance:

When a protected-permissive or permissive-protected left-turn phasing operation is used for a signal system, no information sign is necessary.

Standard:

If a sign is used, it shall be a LEFT TURN YIELD ON GREEN (Green Ball symbol) (R10-12) sign.

Option:

Public agencies having jurisdiction may use an extinguishable message sign on local roads in place of the R10-12 sign on their local roads that are not part of an intersection with a State highway.

Standard:

The message shall say LEFT TURN YIELD in at least 150 mm (6 in) high letters. The light source shall be designed and constructed so that when illuminated, the message shall be white and remain dark when not in use. The message shall be illuminated only when the green permissive ball is lighted.

The following apply to permissive left-turn phasing:

Standard:

1. This operation shall not be initiated where the left turn accident warrant is satisfied.
2. Both directions of through traffic shall be terminated simultaneously except where opposing left turns or opposing U-turns are prohibited.

Guidance:

3. Signal faces should not be placed in a median facing a left turn lane.

Support:

4. Signs are not required for this operation unless U-turns are to be prohibited.

Section C4D.13 Signals at Interchanges

Support:

Signals at freeway interchanges require special consideration as to phasing and timing to minimize backup of traffic onto the freeway lanes.

In addition, signals at diamond-type interchanges require phasing and timing to provide the necessary turning movements from the cross street to and from the ramps, without a backup of traffic between the ramps.

Guidance:

Figures C4D-9 and C4D-10 are guides to be used to determine the timing of traffic signals at diamond interchanges. These figures should be used in conjunction with Table C4D-3 to determine the timing of the splits and offsets for diamond interchange signals.

Support:

The decision whether to use pretimed or traffic-actuated operation is dependent not only upon traffic conditions in the interchange area, but also upon traffic conditions along the cross street. For example, a coordinated traffic signal system along the cross street may require that the signals at the interchange be coordinated with the cross street progression

Section C4D.14 Timing of Green Intervals

Guidance:

The proportion of green time, or split, allotted to each phase or combination of phases during a signal cycle, should be as close as practicable to the proportion of critical lane traffic volumes on the respective approaches. In traffic-actuated operation, this

proportioning is done automatically and continuously as a result of vehicle detector inputs to the controller unit.

Option:

Factors that may modify this proportioning are the time required for pedestrian intervals and the requirements of a coordinated system.

Support:

In the usual signal operation, predetermined splits can be selected by time-of-day or traffic-responsive equipment. In coordinated signal systems, the cycle length and the split can be varied by command from the system master controller.

Section C4D.15 Review of Traffic Signal Operations

Guidance:

All traffic signals should be periodically reviewed for proper operation. The traffic signal operation should be observed during morning and evening peak traffic periods and during off-peak periods. If an operating deficiency is observed, the reason for the deficiency should be determined. If there is a malfunction, Maintenance should be notified, and after corrective work is done, further surveillance should be conducted to be sure no deficiency remains. If a need for a design change is observed, an analysis should be made to determine what improvement might be necessary to improve the design.

Improvements to consider are:

1. Timing of:
 - a. Maximums or Force Offs
 - b. Gap Interval
 - c. Offsets
 - d. Cycle Length
2. Time-of-Day or Traffic Responsive Settings
3. Signal Phasing or Phase Sequence
4. Type of Operation
5. Coordination of Signals
6. Signs, Striping and/or Pavement Markings
7. Roadway Improvements

Standard:

Timing and phasing of traffic signals and any subsequent changes in timing shall be approved by the public agency having jurisdiction. Timing records shall be kept by the agency responsible for the maintenance and/or operation and be readily available to the maintenance and traffic operations staffs and other agencies, where appropriate.

Support:

Aids for timing are shown in Tables C4D-4 and C4D-5.

Section C4D.16 Railroad Preemption

Support:

Railroad preemption results in a special traffic signal operation depending on the relation of the railroad tracks to the intersection, the number of phases in the traffic signal and other traffic conditions. Railroad preemption is normally controlled by the railroad grade crossing warning equipment.

Guidance:

Typical circumstances where railroad preemption is required and the following type of signal operation should be provided during preemption:

1. Where a railroad grade crossing, provided with grade crossing warning equipment, is within 60 m (200 ft) of a signalized intersection, preemption of the traffic signal should provide the following sequence of operation:
 - a. A yellow change interval and any required red clearance interval for any signal phase that is green or yellow when preemption is initiated and which will be red during the track clearance interval. The length of yellow change and red clearance intervals shall not be altered by preemption. Phases, which are in the green interval when preemption is initiated, and which will be green during the track clearance interval, shall remain green. Any pedestrian walk or clearance interval, in effect when preemption is initiated, shall immediately be terminated and all pedestrian signal faces shall display steady upraised HAND.
 - b. A track clearance interval for the signal phase or phases controlling the approach that crosses the railroad tracks. The signal indication for the clearance interval may be either green or flashing red.
 - c. A yellow change interval if green signal indications were provided during the track clearance interval.

- d. Depending on traffic requirements and phasing of the traffic signal controller, the traffic signal may then do one of the following:
 - (1) Go into flashing operation, with flashing red or flashing yellow indications for the approaches parallel to the railroad tracks and flashing red indications for all other approaches. Pedestrian signals shall be extinguished. If flashing red is used for all approaches, an all-red or other clearance interval shall be provided prior to returning to normal operation.
 - (2) Revert to limited operation with those signal indications controlling through and left turn approaches towards the railroad tracks displaying steady red. Permitted pedestrian signal phases shall operate normally. This operation shall be used only if the grade crossing warning equipment includes gates.
 - e. The traffic signal shall return to normal operation following release of preemption control.
- 2. Where the railroad tracks run within a roadway and train speeds exceed 16 km/h (10 mph), preemption of the traffic signal should provide the following sequence of operation.
 - a. A yellow change interval and any required red clearance interval for all signal phases that are green or yellow when preemption is initiated and which will be red during the preemption period. The length of yellow change and red clearance intervals shall not be altered by preemption. Phases, which are in the green interval when preemption is initiated, and which will be green during the preemption period, shall remain green. Any walk or pedestrian clearance intervals in effect when preemption is initiated shall be immediately terminated and all pedestrian signal faces shall display upraised HAND.
 - b. All signal faces controlling traffic movements parallel to the railroad tracks will display green or flashing yellow indications. All other vehicle signal faces will display red indications; pedestrian signal faces will display upraised HAND.
 - 3. Where the railroad tracks run along a roadway of a signalized intersection and train speeds do not exceed 16 km/h (10 mph), trains may be controlled by the vehicle signal indications. This type of train control requires approval from the railroad, the Public Utilities Commission and the Director of Transportation.
 - 4. Unusual or unique track or roadway configurations may require other solutions than those described above.

Section C4D.17 Emergency Vehicle Preemption

Option:

Authorized emergency vehicles may preempt traffic signals. The purpose of such preemption is to provide the right of way to the emergency vehicle as soon as practical. The preemption may be controlled by one of the following means:

1. By direct wire, modulated light or radio from a remote location such as a fire house; and
2. By modulated light or radio from an emergency vehicle.

Guidance:

Emergency vehicle preemption should provide the following sequence of operation:

1. A yellow change interval and any required red clearance interval for any signal phase that is green or yellow when preemption is initiated and which will be red during the preemption interval. The length of the yellow change and red clearance intervals shall not be altered by preemption. Phases, which are in the green interval when preemption is initiated, and which will be green during the preemption period shall remain green. Any pedestrian walk interval in effect when preemption is initiated shall be immediately terminated. The normal pedestrian clearance interval may be abbreviated.

Standard:

2. **An all-red intersection preemption display shall not be used.**
3. **The traffic signal shall return to normal operation upon termination of the demand for preemption or the termination of the assured green interval.**

At a traffic signal provided with both emergency vehicle preemption and railroad preemption, the railroad preemption shall have priority. In the event of a demand for an emergency vehicle preemption during the time that the intersection is operating on railroad preemption, the railroad preemption sequence shall continue unaffected until completion. In the event of a demand for railroad preemption during emergency vehicle preemption operation, railroad preemption shall immediately assume control of the intersection.

When control of emergency vehicle preemption is by means of a radio or modulated light source, the following shall apply:

1. **The transmitter shall be permanently mounted on the emergency vehicle or building and shall operate at a range sufficient to permit a normal yellow change interval and any required clearance intervals to take place prior to**

the arrival of the emergency vehicle. The normal pedestrian clearance interval may be abbreviated.

2. The preemption system may provide an indication (such as a special signal) to the driver of an emergency vehicle that preemption of the traffic signal has been effected. If a special signal light is used, the color shall not be red, yellow, or green.
3. The system shall be designed to prevent simultaneous preemption by two or more emergency vehicles on separate approaches to the intersection.

When performed by a local agency, the installation of emergency vehicle preemption equipment shall be covered by an Encroachment Permit issued by the District Director.

The permit shall state the applicable requirements from those listed above and the following:

1. It should be understood that the permit for the installation might be revoked or changed as deemed advisable or necessary by Caltrans.
2. The timing of the preemption equipment shall be as approved in advance by Caltrans and shall not be changed without written permission. The Permittee shall make any changes in timing, requested by Caltrans.
3. The Permittee shall assume all liability for the claims, which arise due to or because of the permit.

Support:

Normally emergency vehicle preemption equipment is installed, operated, and maintained at no cost to the State. An exception is where the equipment is installed for use by vehicles of another State agency.

Standard:

The State shall maintain the preemption equipment at the traffic signal when the signal is maintained by the State. The costs of such maintenance shall be at 100% local agency expense.

Section C4D.18 Bus/Transit Vehicle Priority

Standard:

The requirements for bus/transit vehicle priority insofar as installation, encroachment permit, maintenance and funding are the same as stated above for

emergency vehicle preemption. The equipment and operation requirements for bus/transit vehicle priority shall be similar to those above for emergency vehicle priority. Some exceptions to these requirements are:

- 1. Equipment requirements for the transmitter are set forth in Section 25352 of the California Vehicle Code.**
- 2. Any pedestrian interval in effect when priority is initiated shall not have its timing affected.**

Guidance:

3. Normally, bus/transit priority should not occur more than once every other signal cycle.

**Figure C4D-1. Left-Turn Phasing Methods
(Phase Diagrams)**

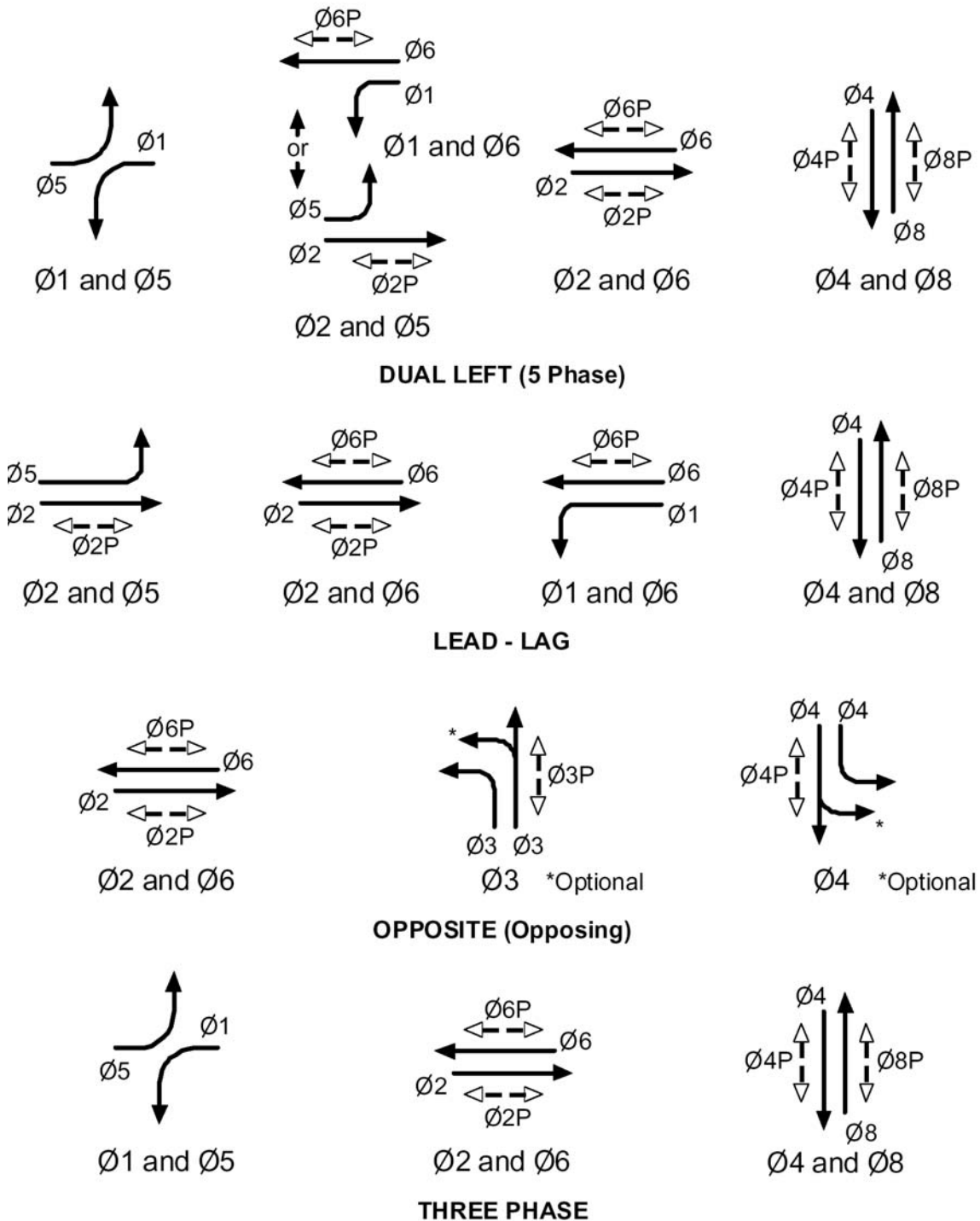
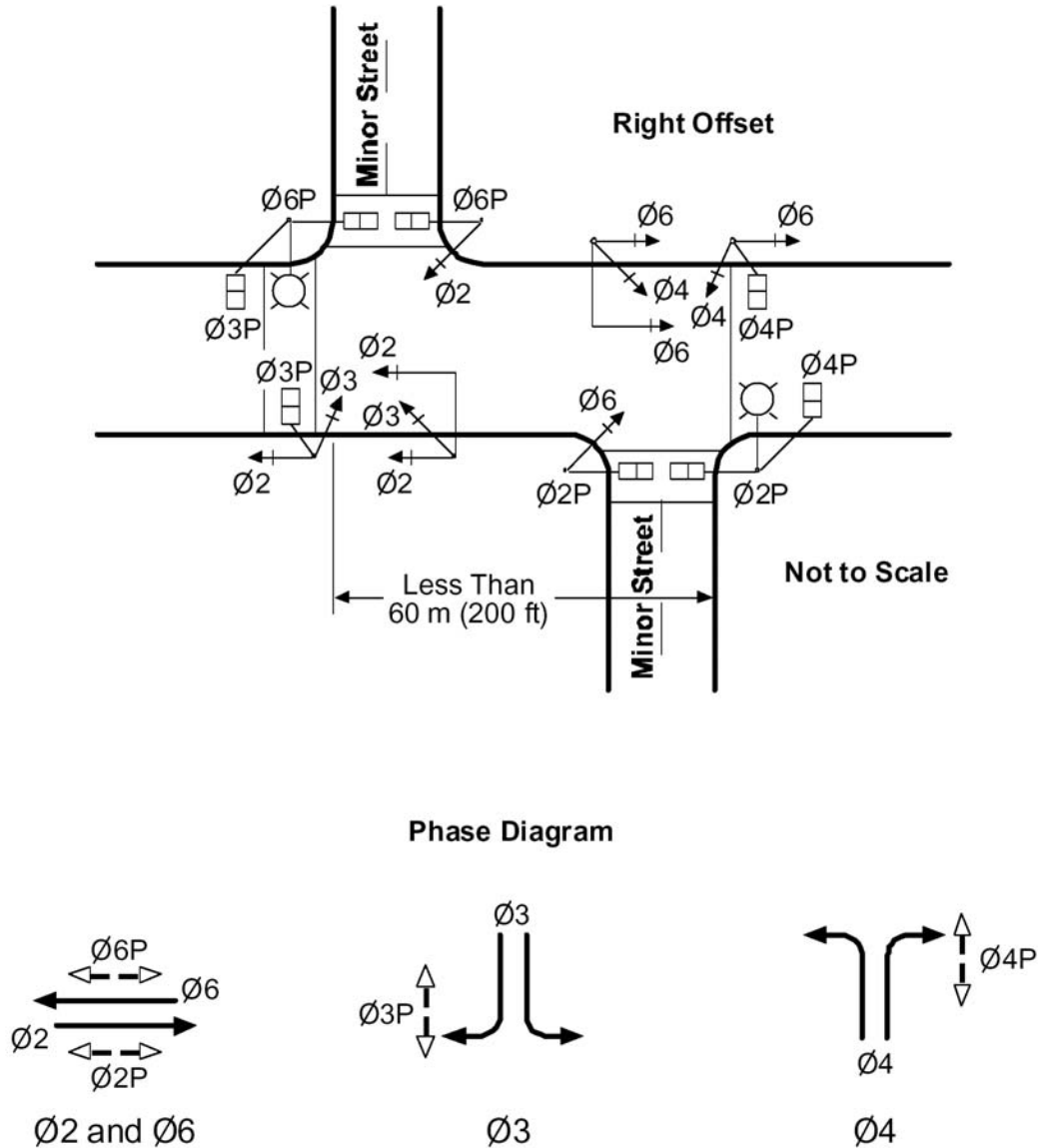
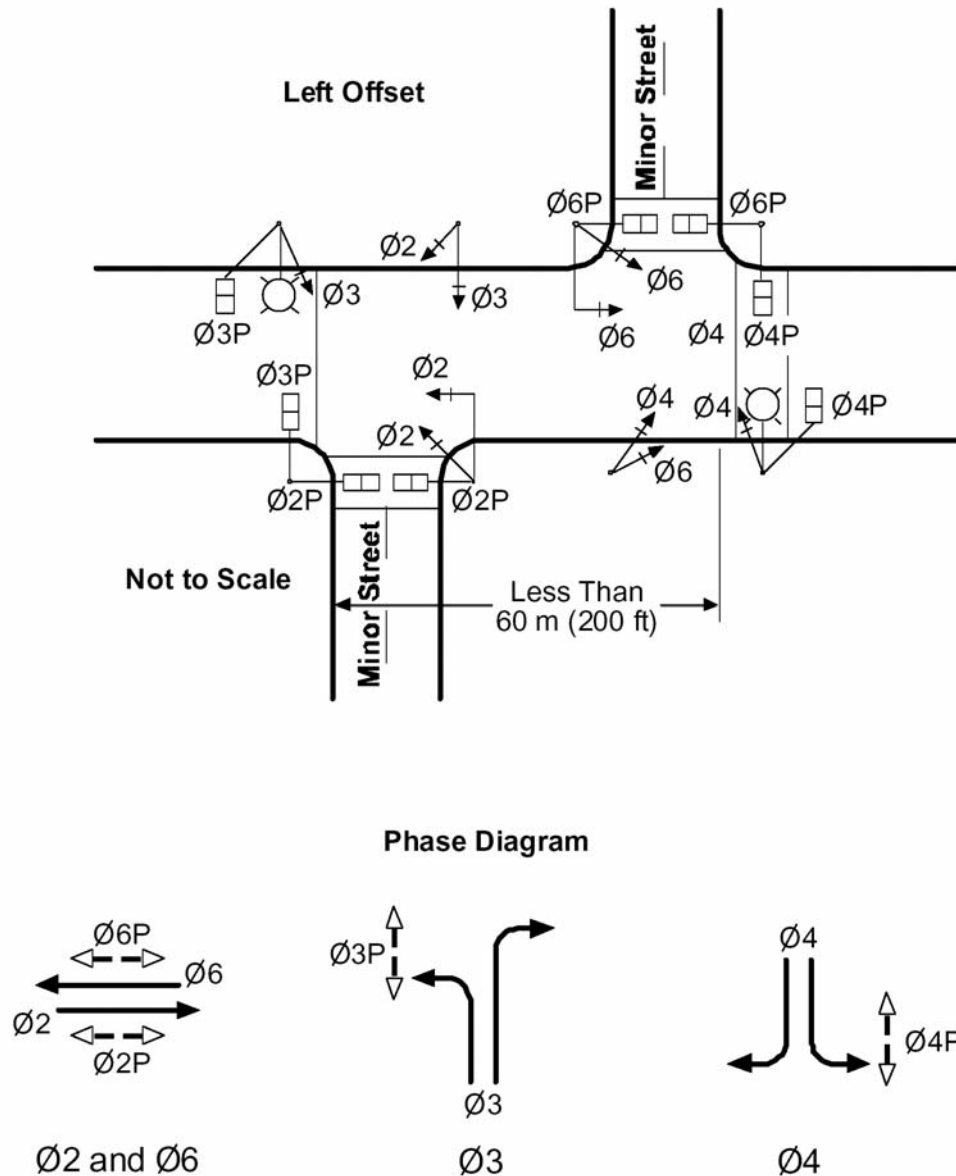


Figure C4D-2. Typical Signal Layout at Offset Intersections, Signalized and Marked as a Single Intersection (Sheet 1 of 4)



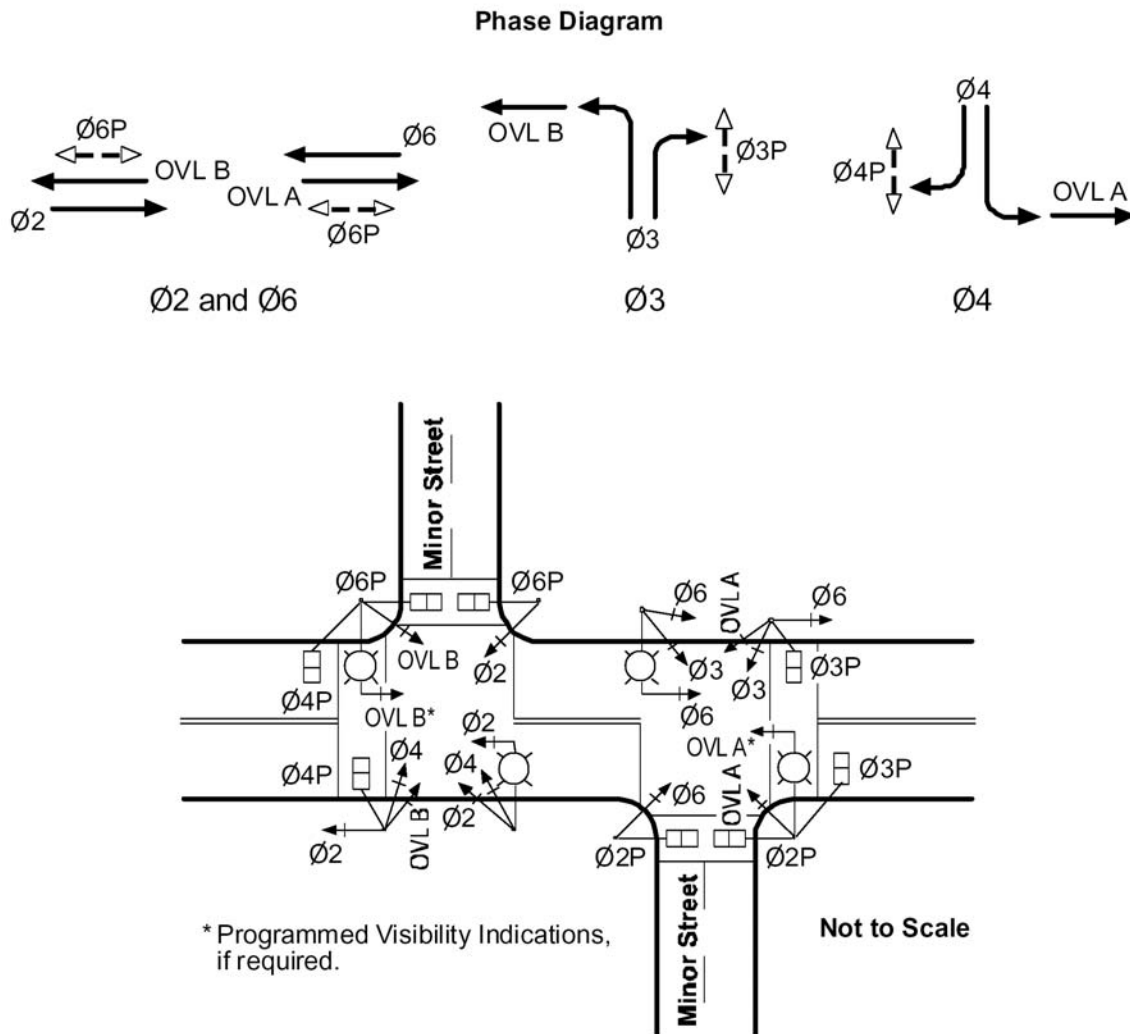
NOTE: Safety Lighting Design shall satisfy the requirements of Volume II, Section 9-10.3.

Figure C4D-3. Typical Signal Layout at Offset Intersections, Signalized and Marked as a Single Intersection (Sheet 2 of 4)



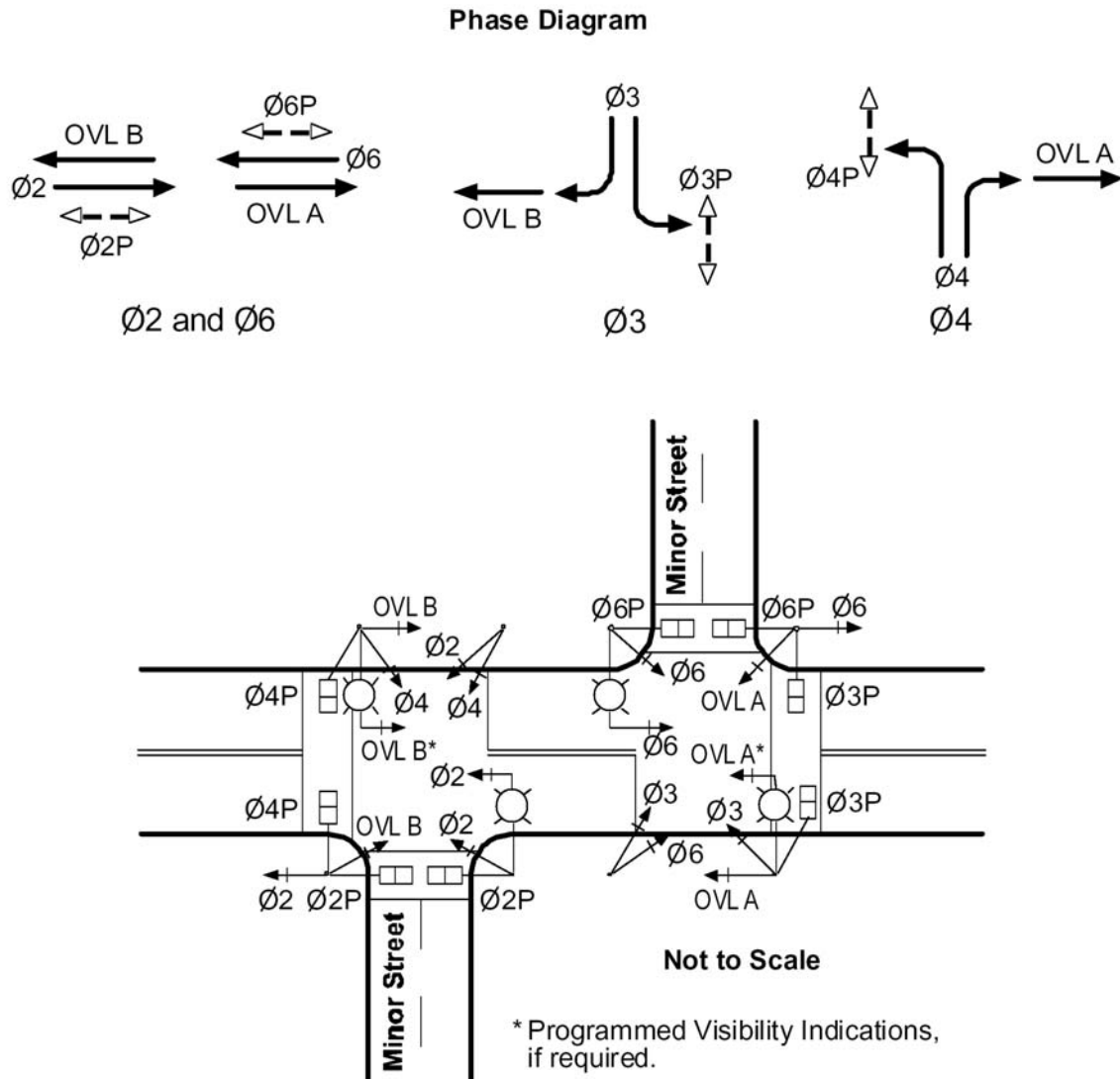
NOTE: Safety Lighting Design shall satisfy the requirements of Volume II, Section 9-10.3.

**Figure C4D-2. Typical Signal Layout at Offset Intersections,
Signalized and Marked as a Single Intersection (Sheet 3 of 4)**



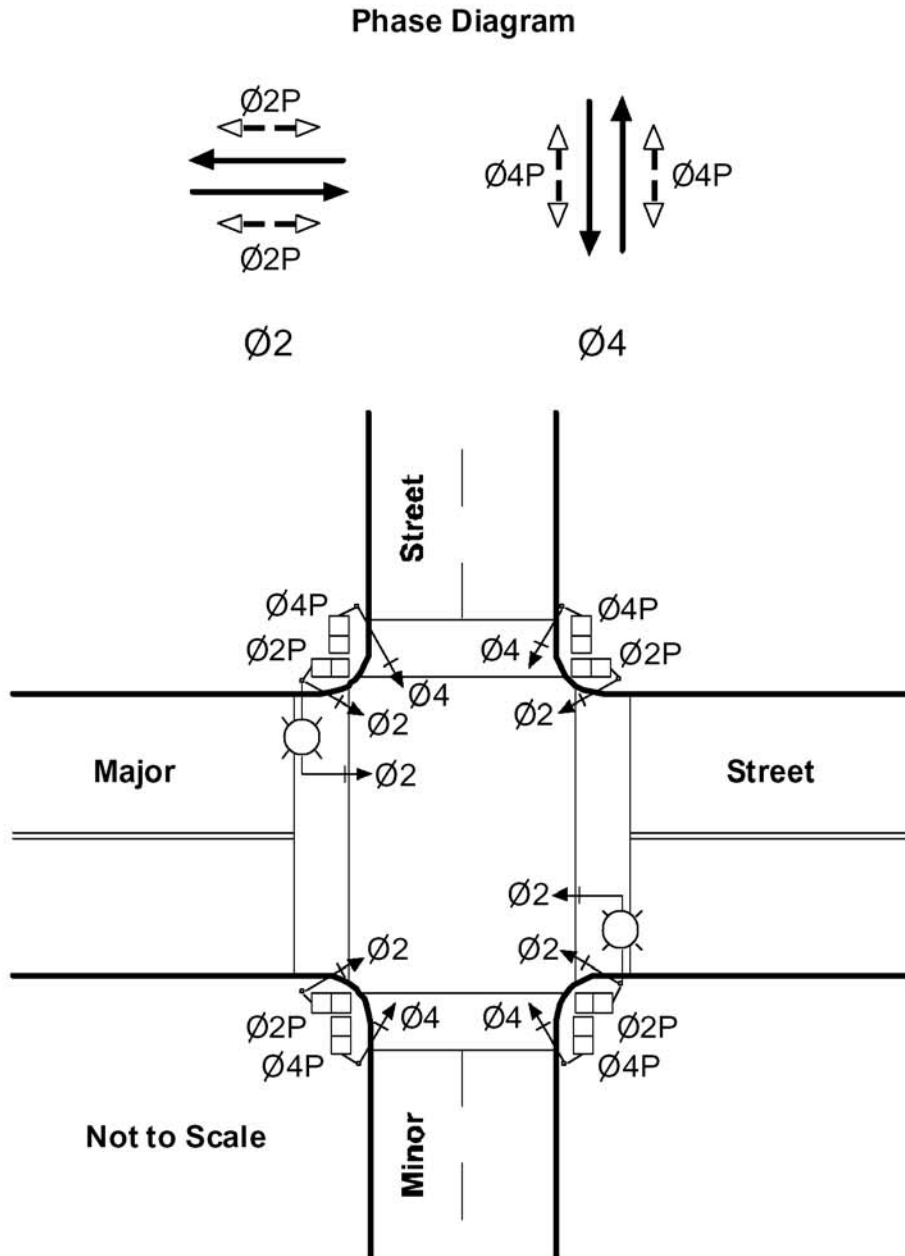
NOTE: Safety Lighting Design shall satisfy the requirements of Volume II, Section 9-10.3.

Figure C4D-2. Typical Signal Layout at Offset Intersections, Signalized and Marked as a Single Intersection (Sheet 4 of 4)



NOTE: Safety Lighting Design shall satisfy the requirements of Volume II, Section 9-10.3.

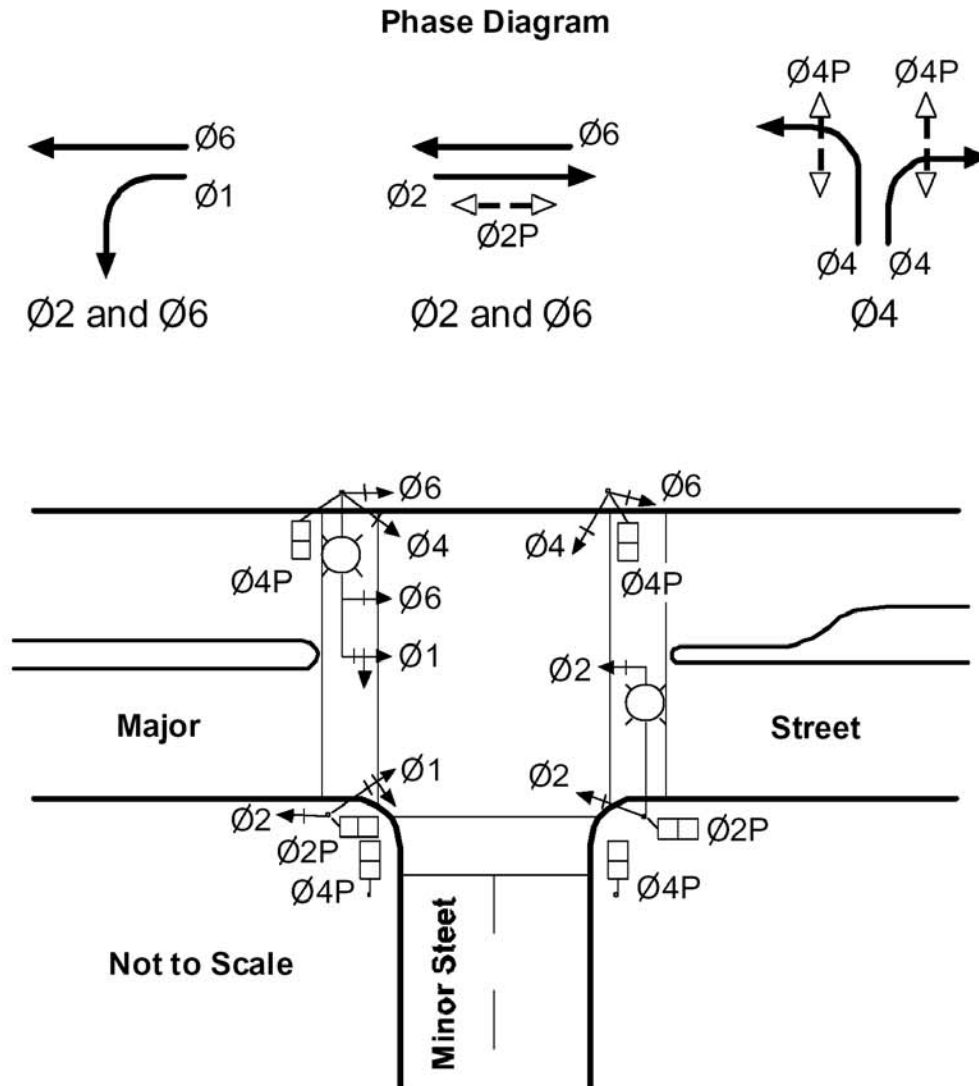
**Figure C4D-3. Typical Signal Layout
(Two Phase Operation)**



LEGEND:

- ←+ Single Face With Backplate
- Pedestrian Signal Face
- ⊙ Standard With Luminaire and Signal Mast Arm

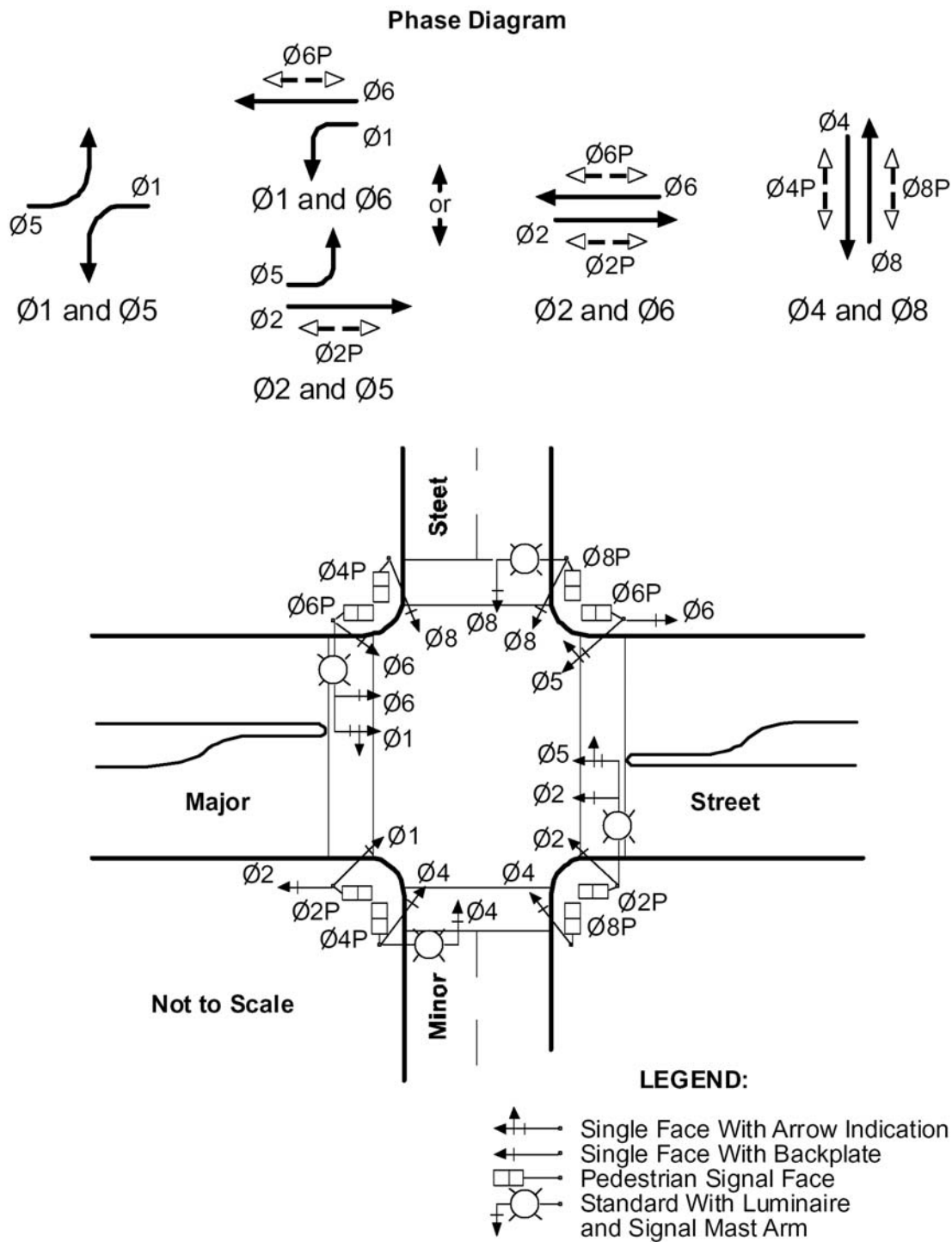
**Figure C4D-4. Typical Signal Layout
(Three Phase Operation)**



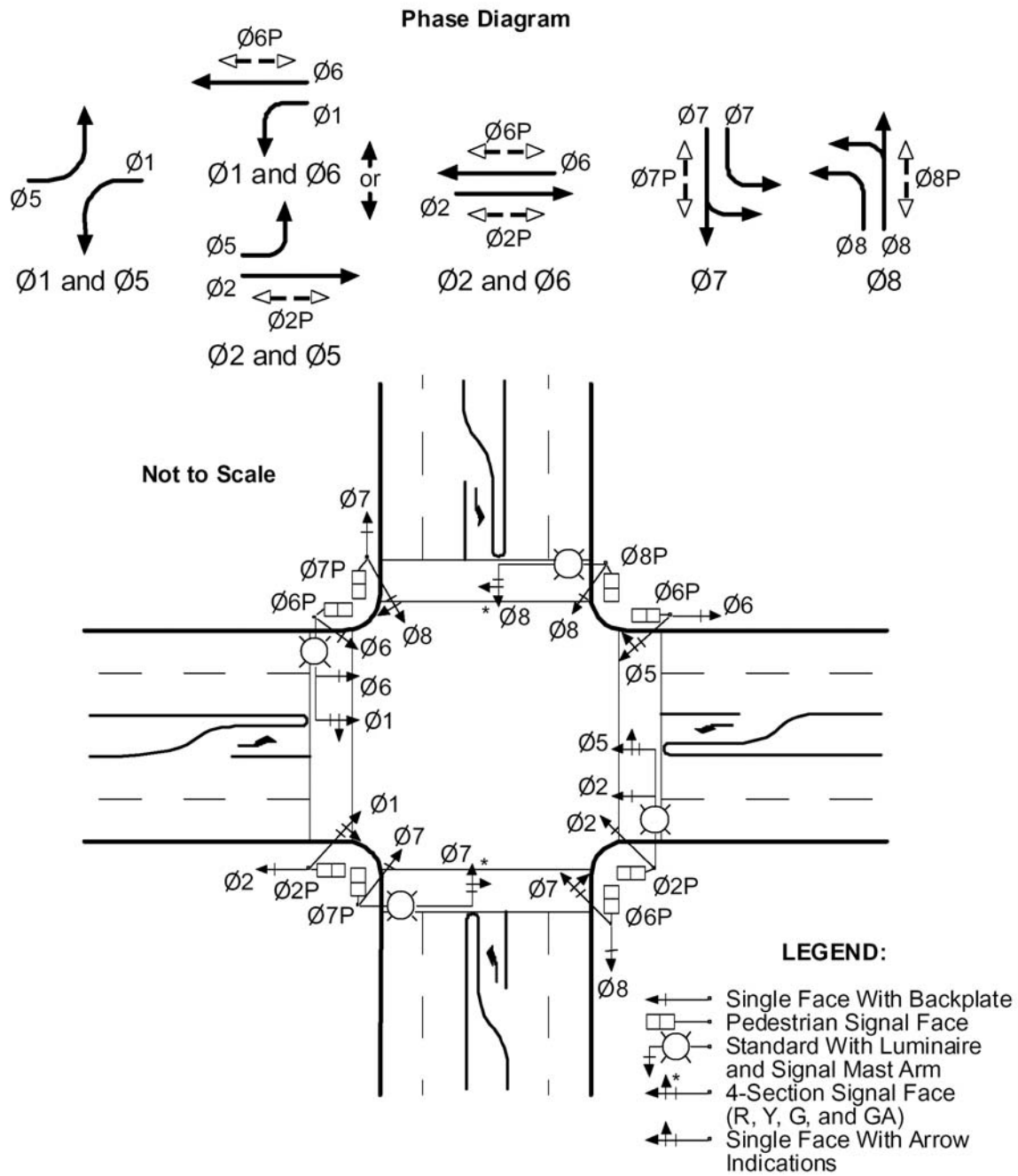
LEGEND:

- Single Face With Arrow Indication
- Single Face With Backplate
- Pedestrian Signal Face
- Standard With Luminaire and Signal Mast Arm

**Figure C4D-5. Typical Signal Layout
(Five Phase "Dual Left" Operation)**



**Figure C4D-6. Typical Signal Layout
(Six Phase "Opposing" Operation)**



**Figure C4D-7. Typical Signal Layout
(Eight Phase "Quad Left" Operation)**

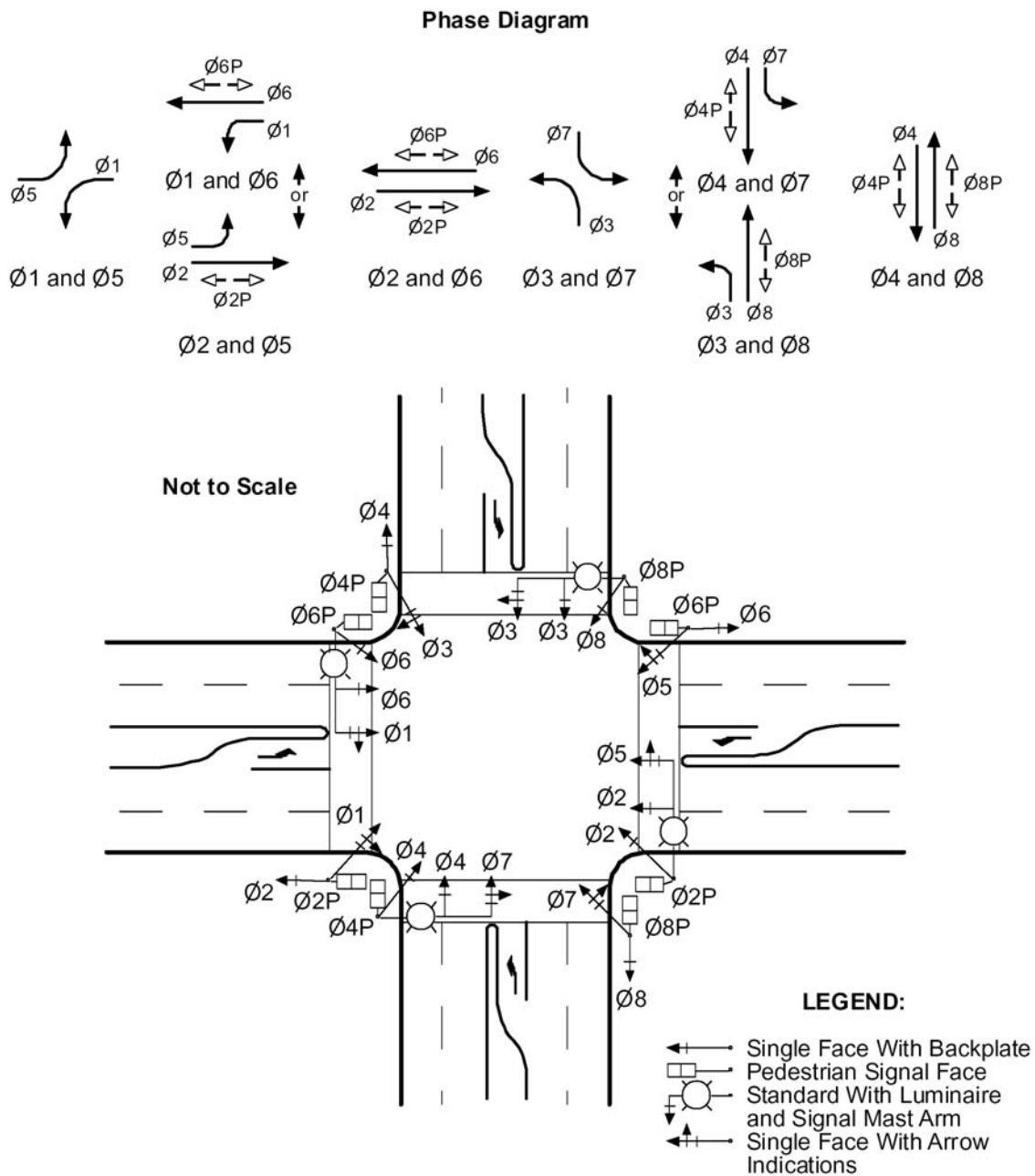
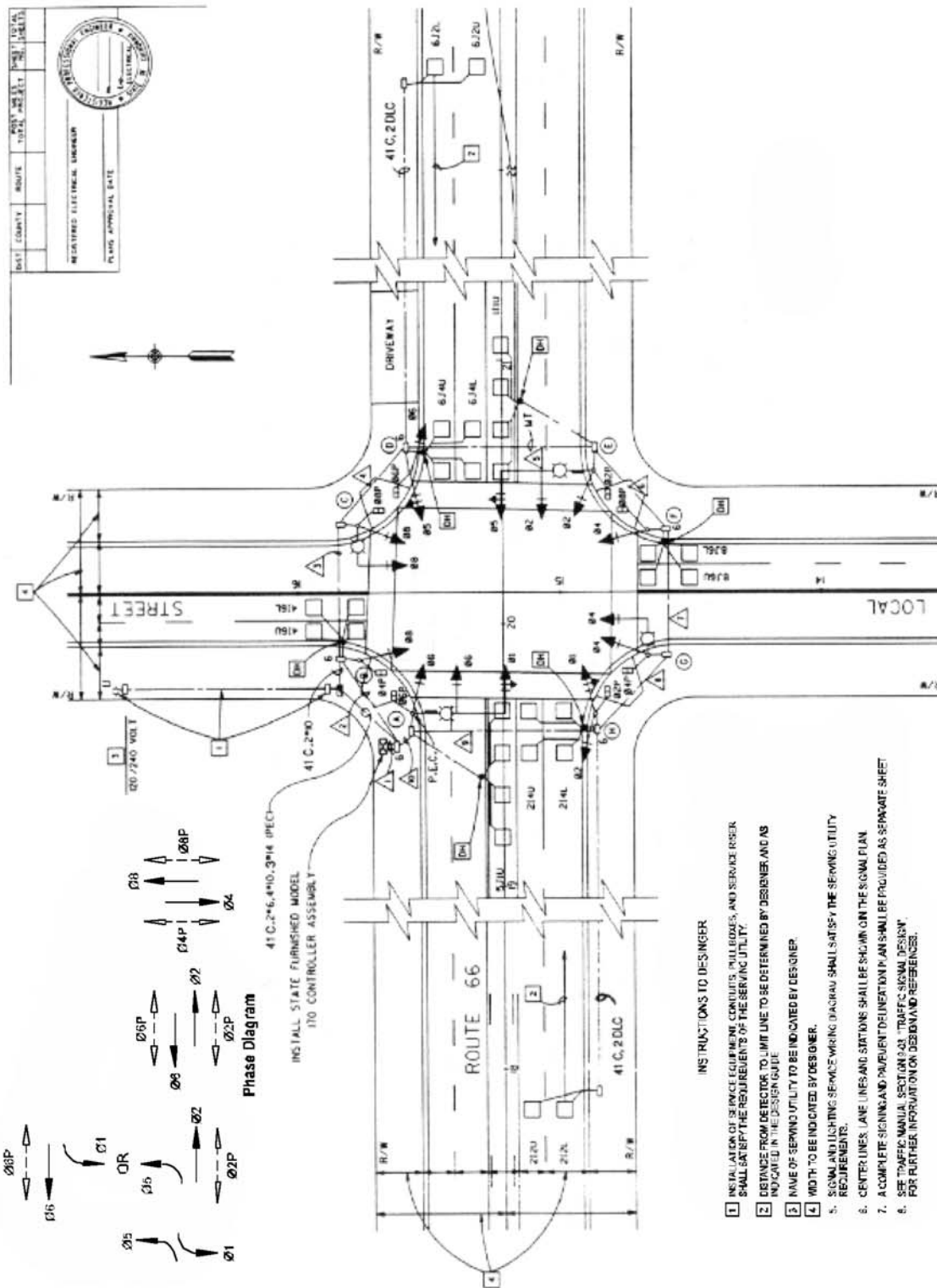
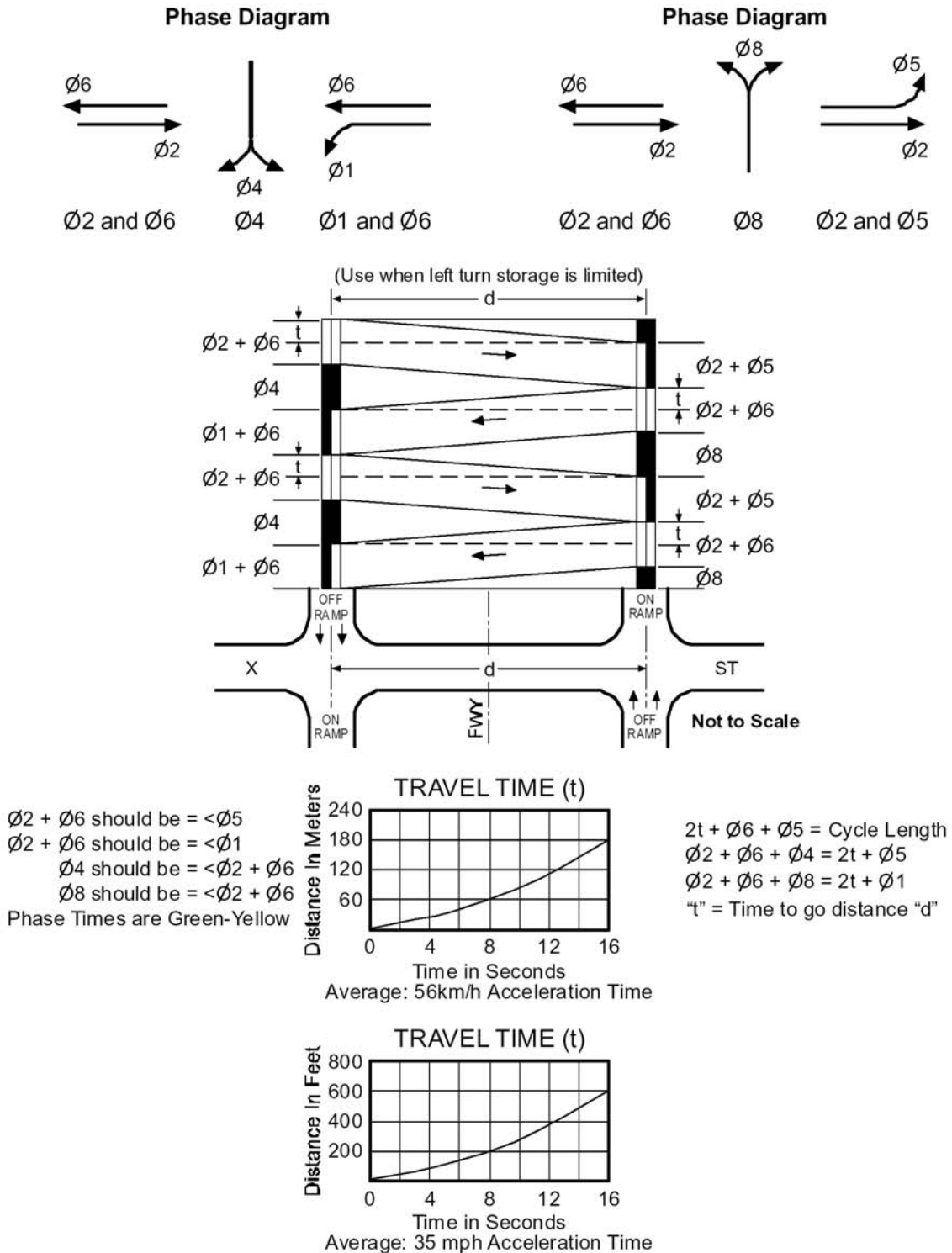


Figure C4D-8. Typical Traffic Signal Installation



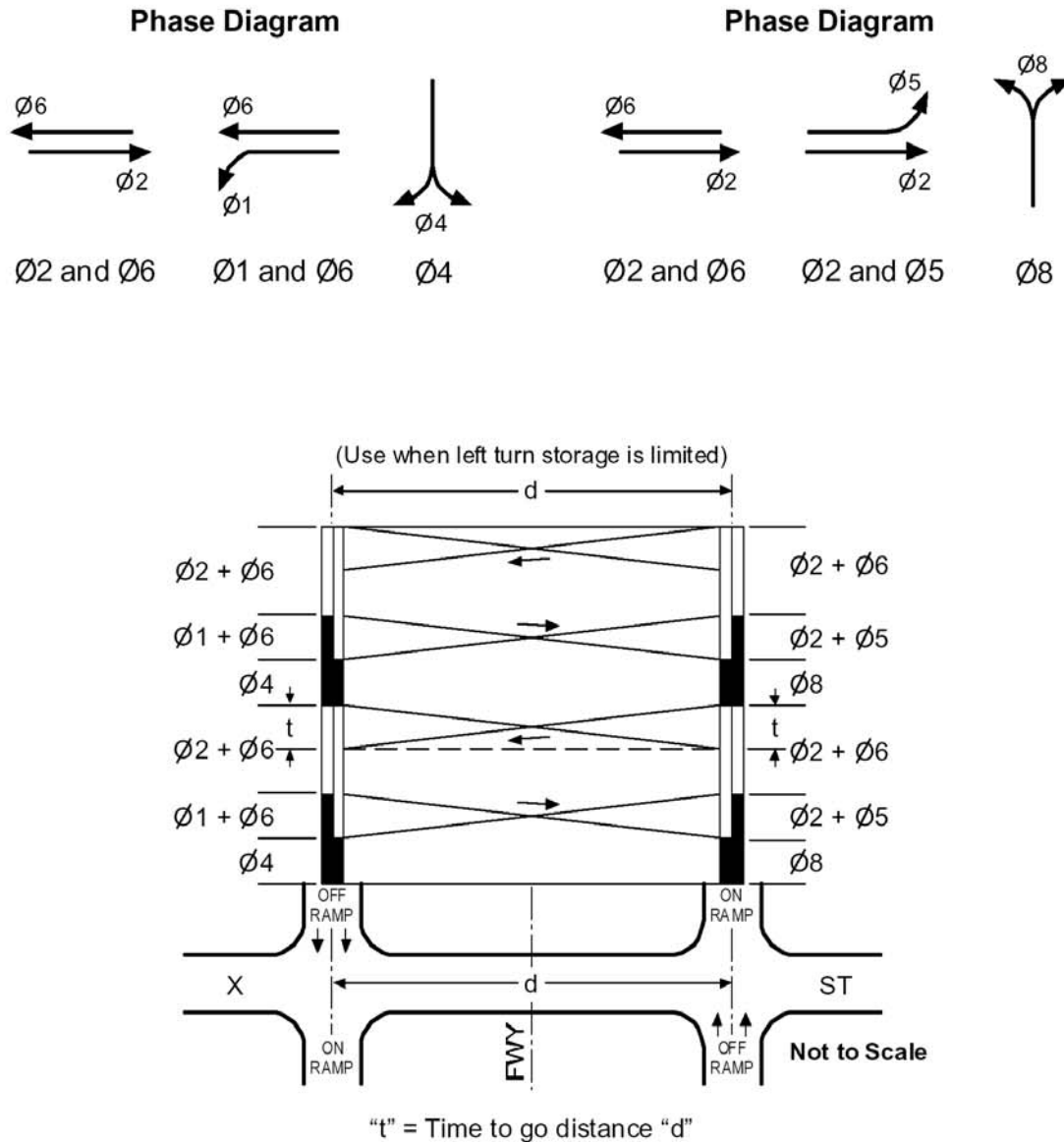
NOTE: This plan accurate for electrical work only.

**Figure C4D-9. Diamond Interchange Timing Chart
(Heavy Left-Turn - 200 vphpl or More - Using Two Controllers)**



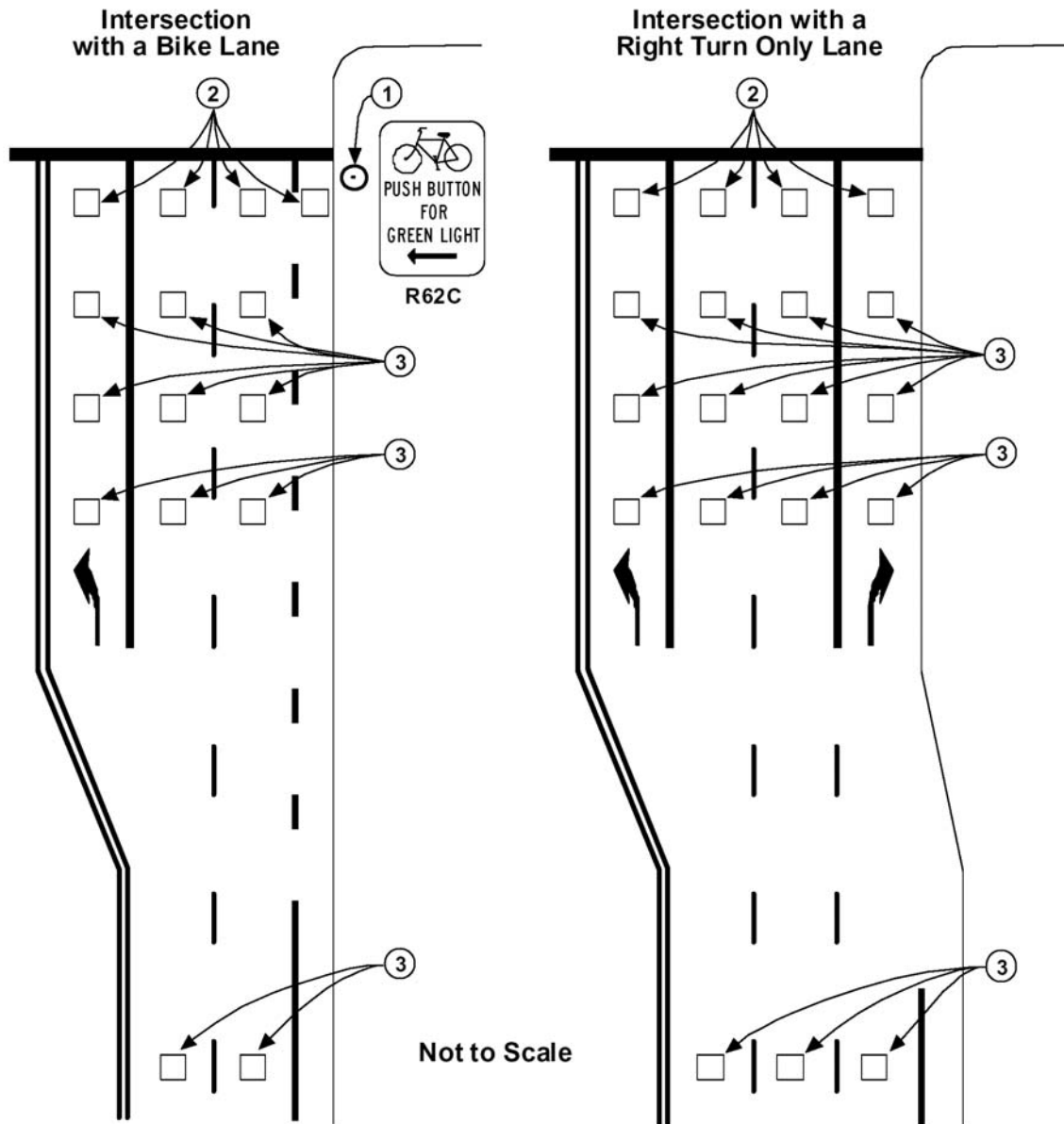
NOTE: These timing guidelines are ideal. Variations in timing may be necessary to provide proper splits to meet volume demands (See Table C4D-1).

**Figure C4D-10. Diamond Interchange Timing Chart
(Light Left-Turn - 200 vphpl or Less - Using Two Controllers)**



- NOTES: 1. These timing guidelines are ideal. Variations in timing may be necessary to provide proper splits to meet volume demands (See Table C4D-1).
2. The Green-Yellow interval for phases 1, 4, 5 or 8 should equal time "t".

Figure C4D-11. Bicycle Detection Systems



NOTES:

1. Bicycle Push Button and Sign (R62C) or a Type D Loop Detector may be used to activate a traffic signal. A push button should be located so it is convenient to use by bicyclists.
2. Typical Type D Loop Detector locations.
3. Typical Loop Detector locations. See Section C4D.09.
4. See Standard Plan A24C for Bicycle Loop Detector pavement marking details.

Table C4D-1. Suggested Detector Setbacks From Limitline

Deceleration Rate $d = 3.05 \text{ m per second}^2$

Reaction Time $r = 1.00 \text{ second}$

Deceleration Distance $= \frac{1}{2}dt^2 \text{ or } \frac{1}{2}Vt \text{ or } \frac{V^2}{2d}$

Deceleration Time $= \frac{V}{d}$

Detector Setback = Deceleration Distance + Reaction Time $= \frac{V^2}{2d} + Vr$

V = Speed (meter per second)

d = Deceleration Rate (meter per second²)

t = Deceleration Time (seconds)

Note: When English units are used, replace “d” (Deceleration Rate) with 10 ft per second². Speed must be expressed in feet per second and the Deceleration Setback will be measured in feet.

SPEED				DEC. TIME	DECELERATION DISTANCE		TOTAL TIME	DETECTOR SETBACK			
mph	km/h	m/s	feet/s		Meters	Feet		ACTUAL		SUGGESTED	
25	40	11.18	36.68	3.67	20.49	66.93	4.67	31.67	103.90	30	105
30	48	13.42	44.00	4.40	29.51	96.82	5.40	42.93	140.80	45	140
35	56	15.65	51.35	5.13	40.17	131.80	6.13	55.82	183.10	55	185
40	64	17.89	58.69	5.87	52.46	204.90	6.87	70.35	230.80	70	230
45	72	20.13	66.04	6.60	66.40	217.80	7.60	86.52	283.90	85	285
50	80	22.36	73.36	7.33	81.97	268.90	8.33	104.33	342.30	105	345
55	89	24.60	80.71	8.06	99.18	325.40	9.06	123.78	406.10	125	405
60	97	26.83	88.00	8.80	118.04	387.30	9.80	144.87	475.30	145	475
65	105	29.07	95.37	9.53	138.53	454.50	10.53	167.60	549.90	170	550
70	113	31.29	102.7	10.27	160.50	526.60	11.27	191.79	649.30	190	650

Table C4D-2. Suggested Minimum Yellow Interval Timing

APPROACH SPEED		YELLOW INTERVAL
mph	km/h	Seconds
25 or less	40 or less	3.0
30	48	3.2
35	56	3.6
40	64	3.9
45	72	4.3
50	80	4.7
55	89	5.0
60	97	5.4
65	105	5.8

Table C4D-3. Traffic Signal Timing Analysis Chart

Number of Cars	Min. Time in Seconds Req. for Cars	Length of Stopped Queue		Length of Moving Queue		Moving Queue Time (Band Width in Seconds)	NUMBER OF VEHICLES PER HOUR LANE AT INDICATED CYCLE LENGTH									
		Meters	Feet	Meters (48 km/h)	Feet (30 mph)		50 Sec.	60 Sec.	70 Sec.	80 Sec.	90 Sec.	100 Sec.	120 Sec.	150 Sec.	180 Sec.	240 Sec.
1	4	8	25	0	0	2	70	60	50	45	40	35	30	25	20	15
2	7	16	50	27	88	4	145	120	100	90	80	70	60	50	40	30
3	9	24	75	54	176	6	215	180	150	135	120	110	90	70	60	45
4	11	32	100	81	264	8	290	240	205	180	160	145	120	95	80	60
5	13	40	125	108	352	10	360	360	255	225	200	180	150	120	100	75
6	15	48	150	135	440	12	430	420	310	270	240	215	180	145	120	90
7	17	54	175	162	528	14	505	480	360	315	280	250	210	170	140	105
8	19	62	200	189	616	16	575	540	410	360	320	290	240	190	160	120
9	21	70	225	216	704	18	650	600	460	405	360	320	270	215	180	135
10	23	78	250	243	792	20	720	660	510	450	400	360	300	240	200	150
11	25	84	275	270	880	22	790	720	560	495	440	400	330	265	220	165
12	27	92	300	297	968	24	865	780	610	540	480	430	360	290	240	180
13	29	100	325	324	1056	26	935	840	665	585	520	470	390	315	260	195
14	31	108	350	351	1144	28	1020	900	715	630	560	500	420	340	280	210
15	33	114	375	378	1232	30	1080	960	765	675	600	540	450	365	300	225
16	35	122	400	405	1320	32	1150	1020	815	720	640	580	480	385	320	240
17	37	130	425	432	1408	34	1225	1080	865	765	680	610	510	410	340	255
18	39	138	450	459	1496	36	1295	1140	920	810	720	650	540	430	360	270
19	41	146	475	486	1584	38		1200	970	855	760	680	570	455	380	285
20	43	154	500	513	1672	40		1260	1020	900	800	720	600	480	400	300
21	45	162	525	540	1760	42		1320	1070	945	840	760	630	505	420	315
22	47	170	550	567	1848	44		1380	1120	990	880	790	660	530	440	330
23	49	178	575	594	1936	46		1440	1175	1035	920	830	690	550	460	345
24	51	186	600	621	2024	48			1225	1080	960	860	720	575	480	360
25	53	194	625	648	2112	50			1275	1125	1000	900	750	600	500	375
26	55	202	650	675	2200	52			1325	1170	1040	930	780	625	520	390
27	57	210	675	702	2288	54			1375	1215	1080	960	810	650	540	405
28	59	218	700	729	2376	56			1430	1260	1120	990	840	670	560	420
29	61	226	725	756	2464	58				1305	1160	1020	870	700	580	435

Table C4D-4. Signal Operations - Vehicular Speed (Sheet 1 of 2)
Metric Units

SECONDS		10	15	20	25	30	35	40	45	50	55	60
km/h	m/s	DISTANCE TRAVELED IN METERS										
1	0.28	2.80	4.20	5.60	7.00	8.40	9.80	11.20	12.60	14.00	15.40	16.80
2	0.56	5.60	8.40	11.20	14.00	16.80	19.60	22.40	25.20	28.00	30.80	33.60
3	0.83	8.30	12.45	16.60	20.75	24.90	29.05	33.20	37.35	41.50	45.65	49.80
4	1.10	11.00	16.50	22.00	27.50	33.00	38.50	44.00	49.50	55.00	60.50	66.00
5	1.39	13.90	20.85	27.80	34.75	41.70	48.65	55.60	62.55	69.50	76.45	83.40
10	2.80	28.00	42.00	56.00	70.00	84.00	98.00	112.00	126.00	140.00	154.00	168.00
15	4.17	41.70	62.60	83.40	104.30	125.00	146.00	167.00	188.00	209.00	229.00	250.00
20	5.56	55.60	84.00	111.00	139.00	167.00	195.00	222.00	250.00	278.00	306.00	334.00
25	6.94	69.40	104.00	139.00	174.00	208.00	243.00	278.00	312.00	347.00	382.00	416.00
30	8.33	83.30	125.00	167.00	208.00	250.00	292.00	333.00	375.00	417.00	458.00	500.00
35	9.72	97.20	146.00	194.00	243.00	292.00	340.00	389.00	437.00	486.00	535.00	583.00
40	11.10	111.00	167.00	222.00	278.00	333.00	389.00	444.00	500.00	555.00	611.00	666.00
45	12.50	125.00	188.00	250.00	313.00	375.00	438.00	500.00	563.00	625.00	688.00	750.00
50	13.89	138.90	208.00	278.00	347.00	417.00	486.00	556.00	625.00	695.00	764.00	834.00
55	15.28	152.80	229.00	306.00	382.00	458.00	535.00	611.00	688.00	764.00	840.00	917.00
60	16.67	166.70	250.00	333.00	416.00	500.00	583.00	667.00	750.00	833.00	917.00	1000.00
65	18.06	180.60	271.00	361.00	452.00	542.00	632.00	722.00	813.00	903.00	993.00	1084.00
70	19.44	194.40	292.00	389.00	486.00	583.00	680.00	778.00	875.00	972.00	1069.00	1166.00
75	20.83	208.30	312.00	417.00	521.00	625.00	729.00	833.00	937.00	1042.00	1146.00	1250.00
80	22.22	222.20	333.00	444.00	555.00	667.00	778.00	889.00	1000.00	1111.00	1222.00	1333.00
85	23.61	236.10	354.00	472.00	590.00	708.00	826.00	944.00	1062.00	1180.00	1298.00	1416.00
90	25.00	250.00	375.00	500.00	625.00	750.00	875.00	1000.00	1125.00	1250.00	1375.00	1500.00
95	26.39	263.90	396.00	528.00	660.00	792.00	924.00	1056.00	1188.00	1320.00	1452.00	1584.00
100	27.78	277.80	417.00	556.00	695.00	834.00	972.00	1112.00	1251.00	1390.00	1529.00	1668.00
105	29.17	291.70	437.00	583.00	729.00	875.00	1021.00	1167.00	1313.00	1458.00	1604.00	1750.00
110	30.56	305.60	458.00	611.00	764.00	917.00	1070.00	1222.00	1375.00	1528.00	1681.00	1834.00

Table C4D-4. Signal Operations - Vehicular Speed (Sheet 2 of 2)
English Units

SECONDS		10	15	20	25	30	35	40	45	50	55	60
mph	ft/s	DISTANCE TRAVELED IN FEET										
1	1.46	14.6	21.9	29.3	36.6	44.0	51.3	58.6	66.0	73.3	80.6	88.0
2	2.93	29.3	44.0	58.6	73.3	88.0	102.6	117.3	132.0	146.6	161.3	176.0
3	4.40	44.0	66.0	88.0	110.0	132.0	154.0	176.0	198.0	220.0	242.0	264.0
4	5.86	58.6	88.0	117.3	146.6	176.0	205.3	234.6	264.0	293.3	322.6	352.0
5	7.30	73.0	110.0	147.0	183.0	220.0	257.0	293.0	330.0	367.0	403.0	440.0
10	14.60	146.0	220.0	293.0	366.0	440.0	513.0	587.0	660.0	733.0	807.0	880.0
15	22.00	220.0	330.0	440.0	550.0	660.0	770.0	880.0	990.0	1,100.0	1,210.0	1,320.0
20	29.30	293.0	440.0	587.0	733.0	880.0	1,027.0	1,173.0	1,320.0	1,467.0	1,613.0	1,760.0
25	36.70	367.0	550.0	733.0	917.0	1,100.0	1,283.0	1,467.0	1,650.0	1,833.0	2,017.0	2,200.0
30	44.00	440.0	660.0	880.0	1,100.0	1,320.0	1,540.0	1,760.0	1,980.0	2,200.0	2,420.0	2,640.0
35	51.30	513.0	770.0	1,027.0	1,283.0	1,540.0	1,797.0	2,053.0	2,310.0	2,567.0	2,823.0	3,080.0
40	58.70	587.0	880.0	1,173.0	1,467.0	1,760.0	2,053.0	2,347.0	2,640.0	2,933.0	3,227.0	3,520.0
45	66.00	660.0	990.0	1,320.0	1,650.0	1,980.0	2,310.0	2,640.0	2,970.0	3,300.0	3,630.0	3,960.0
50	73.30	733.0	1,100.0	1,467.0	1,833.0	2,200.0	2,567.0	2,933.0	3,300.0	3,667.0	4,033.0	4,400.0
55	80.70	807.0	1,210.0	1,613.0	2,017.0	2,420.0	2,823.0	3,227.0	3,630.0	4,033.0	4,437.0	4,840.0
60	88.00	880.0	1,320.0	1,760.0	2,200.0	2,640.0	3,080.0	3,520.0	3,960.0	4,400.0	4,840.0	5,280.0
65	95.30	953.0	1,430.0	1,907.0	2,383.0	2,860.0	3,337.0	3,813.0	4,290.0	4,767.0	5,243.0	5,720.0
70	102.70	1,027.0	1,540.0	2,053.0	2,567.0	3,080.0	3,593.0	4,107.0	4,620.0	5,133.0	5,647.0	6,160.0
75	110.00	1,100.0	1,650.0	2,200.0	2,750.0	3,300.0	3,850.0	4,400.0	4,950.0	5,500.0	6,050.0	6,600.0
80	117.30	1,173.0	1,760.0	2,347.0	2,933.0	3,520.0	4,107.0	4,693.0	5,280.0	5,867.0	6,453.0	7,040.0
85	124.70	1,247.0	1,870.0	2,493.0	3,117.0	3,740.0	4,363.0	4,987.0	5,610.0	6,233.0	6,858.0	7,480.0
90	132.00	1,320.0	1,980.0	2,640.0	3,300.0	3,960.0	4,620.0	5,280.0	5,940.0	6,600.0	7,260.0	7,920.0
95	139.30	1,393.0	2,090.0	2,787.0	3,483.0	4,180.0	4,877.0	5,573.0	6,270.0	6,967.0	7,663.0	8,360.0
100	146.70	1,467.0	2,200.0	2,933.0	3,667.0	4,400.0	5,133.0	5,867.0	6,600.0	7,333.0	8,067.0	8,800.0
105	154.00	1,540.0	2,310.0	3,080.0	3,850.0	4,620.0	5,390.0	6,160.0	6,930.0	7,700.0	8,470.0	9,240.0
110	161.30	1,613.0	2,420.0	3,227.0	4,033.0	4,840.0	5,647.0	6,453.0	7,260.0	8,067.0	8,873.0	9,680.0
115	168.60	1,686.0	2,530.0	3,373.0	4,217.0	5,060.0	5,903.0	6,747.0	7,590.0	8,434.0	9,277.0	10,120.0
120	176.00	1,760.0	2,640.0	3,520.0	4,400.0	5,280.0	6,160.0	7,040.0	7,920.0	8,800.0	9,680.0	10,560.0

**Table C4D-5. Signal Operation - Cycle Percentage Conversion
(Sheet 1 of 2)**

PERCENT	50	60	70	80	90	100	110	120	150	180	240
1	0.5	0.6	0.7	0.8	0.9	1.0	1.1	1.2	1.5	1.8	2.4
2	1.0	1.2	1.4	1.6	1.8	2.0	2.2	2.4	3.0	3.6	4.8
3	1.5	1.8	2.1	2.4	2.7	3.0	3.3	3.6	4.5	5.4	7.2
4	2.0	2.4	2.8	3.2	3.6	4.0	4.4	4.8	6.0	7.2	9.6
5	2.5	3.0	3.5	4.0	4.5	5.0	5.5	6.0	7.5	9.0	12.0
6	3.0	3.6	4.2	4.8	5.4	6.0	6.6	7.2	9.0	10.8	14.4
7	3.5	4.2	4.9	5.6	6.3	7.0	7.7	8.4	10.5	12.6	16.8
8	4.0	4.8	5.6	6.4	7.2	8.0	8.8	9.6	12.0	14.4	19.2
9	4.5	5.4	6.3	7.2	8.1	9.0	9.9	10.8	13.5	16.2	21.6
10	5.0	6.0	7.0	8.0	9.0	10.0	11.0	12.0	15.0	18.0	24.0
11	5.5	6.6	7.7	8.8	9.9	11.0	12.1	13.2	16.5	19.8	26.4
12	6.0	7.2	8.4	9.6	10.8	12.0	13.2	14.4	18.0	21.6	28.8
13	6.5	7.8	9.1	10.4	11.7	13.0	14.3	15.6	19.5	23.4	31.2
14	7.0	8.4	9.8	11.2	12.6	14.0	15.4	16.8	21.0	25.2	33.6
15	7.5	9.0	10.5	12.0	13.5	15.0	16.5	18.0	22.5	27.0	36.0
16	8.0	9.6	11.2	12.8	14.4	16.0	17.6	19.2	24.0	28.8	38.4
17	8.5	10.2	11.9	13.6	15.3	17.0	18.7	20.4	25.5	30.6	40.8
18	9.0	10.8	12.6	14.4	16.2	18.0	19.8	21.6	27.0	32.4	43.2
19	9.5	11.4	13.3	15.2	17.1	19.0	20.9	22.8	28.5	34.2	45.6
20	10.0	12.0	14.0	16.0	18.0	20.0	22.0	24.0	30.0	36.0	48.0
21	10.5	12.6	14.7	16.8	18.9	21.0	23.1	25.2	31.5	37.8	50.4
22	11.0	13.2	15.4	17.6	19.8	22.0	24.2	26.4	33.0	39.6	52.8
23	11.5	13.8	16.1	18.4	20.7	23.0	25.3	27.6	34.5	41.4	55.2
24	12.0	14.4	16.8	19.2	21.6	24.0	26.4	28.8	36.0	43.2	57.6
25	12.5	15.0	17.5	20.0	22.5	25.0	27.5	30.0	37.5	45.0	60.0
26	13.0	15.6	18.2	20.8	23.4	26.0	28.6	31.2	39.0	46.8	62.4
27	13.5	16.2	18.9	21.6	24.3	27.0	29.7	32.4	40.5	48.6	64.8
28	14.0	16.8	19.6	22.4	25.2	28.0	30.8	33.6	42.0	50.4	67.2
29	14.5	17.4	20.3	23.2	26.1	29.0	31.9	34.8	43.5	52.2	69.6
30	15.0	18.0	21.0	24.0	27.0	30.0	33.0	36.0	45.0	54.0	72.0
31	15.5	18.6	21.7	24.8	27.9	31.0	34.1	37.2	46.5	55.8	74.4
32	16.0	19.2	22.4	25.6	28.8	32.0	35.2	38.4	48.0	57.6	76.8
33	16.5	19.8	23.1	26.4	29.7	33.0	36.3	39.6	49.5	59.4	79.2
34	17.0	20.4	23.8	27.2	30.6	34.0	37.4	40.8	51.0	61.2	81.6
35	17.5	21.0	24.5	28.0	31.5	35.0	38.5	42.0	52.5	63.0	84.0
36	18.0	21.6	25.2	28.8	32.4	36.0	39.6	43.2	54.0	64.8	86.4
37	18.5	22.2	25.9	29.6	33.3	37.0	40.7	44.4	55.5	66.6	88.8
38	19.0	22.8	26.6	30.4	34.2	38.0	41.8	45.6	57.0	68.4	91.2
39	19.5	23.4	27.3	31.2	35.1	39.0	42.9	46.8	58.5	70.2	93.6
40	20.0	24.0	28.0	32.0	36.0	40.0	44.0	48.0	60.0	72.0	96.0
41	20.5	24.6	28.7	32.8	36.9	41.0	45.1	49.2	61.5	73.8	96.4
42	21.0	25.2	29.4	33.6	37.8	42.0	46.2	50.4	63.0	75.6	100.8
43	21.5	25.8	30.1	34.4	38.7	43.0	47.3	51.6	64.5	77.4	103.2
44	22.0	26.4	30.8	35.2	39.6	44.0	48.4	52.8	66.0	79.2	105.6
45	22.5	27.0	31.5	36.0	40.5	45.0	49.5	54.0	67.5	81.0	108.0
46	23.0	27.6	32.2	36.8	41.4	46.0	50.6	55.2	69.0	82.8	110.4
47	23.5	28.2	32.9	37.6	42.3	47.0	51.7	56.4	70.5	84.6	112.8
48	24.0	28.8	33.6	38.4	43.2	48.0	52.8	57.6	72.0	86.4	115.2
49	24.5	29.4	34.3	39.2	44.1	49.0	53.9	58.8	73.5	88.2	117.6
50	25.0	30.0	35.0	40.0	45.0	50.0	55.0	60.0	75.0	90.0	120.0

**Table C4D-5. Signal Operation - Cycle Percentage Conversion
(Sheet 2 of 2)**

PERCENT	50	60	70	80	90	100	110	120	150	180	240
51	25.5	30.6	35.7	40.8	45.9	51.0	56.1	61.2	76.5	91.8	122.4
52	26.0	31.2	36.4	41.6	46.8	52.0	57.2	62.4	78.0	93.6	124.8
53	26.5	31.8	37.1	42.4	47.7	53.0	58.3	63.6	79.5	95.4	127.2
54	27.0	32.4	37.8	43.2	48.6	54.0	59.4	64.8	81.0	97.2	129.6
55	27.5	33.0	38.5	44.0	49.5	55.0	60.5	66.0	82.5	99.0	132.0
56	28.0	33.6	39.2	44.8	50.4	56.0	61.6	67.2	84.0	100.8	134.4
57	28.5	34.2	39.9	45.6	51.3	57.0	62.7	68.4	85.5	102.6	136.8
58	29.0	34.8	40.6	46.4	52.2	58.0	63.8	69.6	87.0	104.4	139.2
59	29.5	35.4	41.3	47.2	53.1	59.0	64.9	70.8	88.5	106.2	141.6
60	30.0	36.0	42.0	48.0	54.0	60.0	66.0	72.0	90.0	108.0	144.0
61	30.5	36.6	42.7	48.8	54.9	61.0	67.1	73.2	91.5	109.8	146.4
62	31.0	37.2	43.4	49.6	55.8	62.0	68.2	74.4	93.0	111.6	148.8
63	31.5	37.8	44.1	50.4	56.7	63.0	69.3	75.6	94.5	113.4	151.2
64	32.0	38.4	44.8	51.2	57.6	64.0	70.4	76.8	96.0	115.2	153.6
65	32.5	39.0	45.5	52.0	58.5	65.0	71.5	78.0	97.5	117.0	156.0
66	33.0	39.6	46.2	52.8	59.4	66.0	72.6	79.2	99.0	118.8	158.4
67	33.5	40.2	46.9	53.6	60.3	67.0	73.7	80.4	100.5	120.6	160.8
68	34.0	40.8	47.6	54.4	61.2	68.0	74.8	81.6	102.0	122.4	163.2
69	34.5	41.4	48.3	55.2	62.1	69.0	75.9	82.8	103.5	124.2	165.6
70	35.0	42.0	49.0	56.0	63.0	70.0	77.0	84.0	105.0	126.0	168.0
71	35.5	42.6	49.7	56.8	63.9	71.0	78.1	85.2	106.5	127.8	170.4
72	36.0	43.2	50.4	57.6	64.8	72.0	79.2	86.4	108.0	129.6	172.8
73	36.5	43.8	51.1	58.4	65.7	73.0	80.3	87.6	109.5	131.4	175.2
74	37.0	44.4	51.8	59.2	66.6	74.0	81.4	88.8	111.0	133.2	177.6
75	37.5	45.0	52.5	60.0	67.5	75.0	82.5	90.0	112.5	135.0	180.0
76	38.0	45.6	53.2	60.8	68.4	76.0	83.6	91.2	114.0	136.8	182.4
77	38.5	46.2	53.9	61.6	69.3	77.0	84.7	92.4	115.5	138.6	184.8
78	39.0	46.8	54.6	62.4	70.2	78.0	85.8	93.6	117.0	140.4	187.2
79	39.5	47.4	55.3	63.2	71.1	79.0	86.9	94.8	118.5	142.2	189.6
80	40.0	48.0	56.0	64.0	72.0	80.0	88.0	96.0	120.0	144.0	192.0
81	40.5	48.6	56.7	64.8	72.9	81.0	89.1	97.2	121.5	145.8	194.4
82	41.0	49.2	57.4	65.6	73.8	82.0	90.2	98.4	123.0	147.6	196.8
83	41.5	49.8	58.1	66.4	74.7	83.0	91.3	99.6	124.5	149.4	199.2
84	42.0	50.4	58.8	67.2	75.6	84.0	92.4	100.8	126.0	151.2	201.6
85	42.5	51.0	59.5	68.0	76.5	85.0	93.5	102.0	127.5	153.0	204.0
86	43.0	51.6	60.2	68.8	77.4	86.0	94.6	103.2	129.0	154.8	206.4
87	43.5	52.2	60.9	69.6	78.3	87.0	95.7	104.4	130.5	156.6	208.8
88	44.0	52.8	61.6	70.4	79.2	88.0	96.8	105.6	132.0	158.4	211.2
89	44.5	53.4	62.3	71.2	80.1	89.0	97.9	106.8	133.5	160.2	213.6
90	45.0	54.0	63.0	72.0	81.0	90.0	99.0	108.0	135.0	162.0	216.0
91	45.5	54.6	63.7	72.8	81.9	91.0	100.1	109.2	136.5	163.8	218.4
92	46.0	55.2	64.4	73.6	82.8	92.0	101.2	110.4	138.0	165.6	220.8
93	46.5	55.8	65.1	74.4	83.7	93.0	102.3	111.6	139.5	167.4	223.2
94	47.0	56.4	65.8	75.2	84.6	94.0	103.4	112.8	141.0	169.2	225.6
95	47.5	57.0	66.5	76.0	85.5	95.0	104.5	114.0	142.5	171.0	228.0
96	48.0	57.6	67.2	76.8	86.4	96.0	105.6	115.2	144.0	172.8	230.4
97	48.5	58.2	67.9	77.6	87.3	97.0	106.7	116.4	145.5	174.6	232.8
98	49.0	58.8	68.6	78.4	88.2	98.0	107.8	117.6	147.0	176.4	235.2
99	49.5	59.4	69.3	79.2	89.1	99.0	108.9	118.8	148.5	178.2	237.6

Table C4D-6. Pole and Equipment Schedule

	STANDARD						VEHICLE SIGNAL MAST		PED. SIGNAL MTG.	PPB		HPS LUM.	SPECIAL REQUIREMENTS
	TYPE		SIGNAL MAST ARM		LUMINAIRE MAST ARM					Ø	ARROW		
	Wind Velocity km/h	Wind Velocity mph	Meters	Feet	Meters	Feet	MAST	POLE					
A	24-4-129	24-4-80	10.7	35	3.7	12	MAT MAS	SV-1-T	SP-1-T	4	←	200W	Interally Illuminated Street Name Sign "Local Streets"
B	1A							TV-1-T	SP-1-T	6	→		
C	19-1-129	19-1-80	4.6	15	3.7	12	MAS	SV-1-T	SP-1-T	6	←	200W	
D	1A							TV-1-T	SP-1-T	8	→		
E	24-4-129	24-4-80	10.7	35	3.7	12	MAT MAS	SV-1-T	SP-1-T	8	←	200W	Interally Illuminated Street Name Sign "Local Streets"
F	1A							TV-1-T	SP-1-T	2	→		
G	19-1-129	19-1-80	4.6	15	3.7	12	MAS	SV-1-T	SP-1-T	2	←	200W	
H	1A							TV-1-T	SP-1-T	4	→		

Note: Designer should verify structure requirements before adding side mounting vehicle signals.

Table C4D-7. Conductor and Conduit Schedule

AWG or CABLE	CONDUCTOR RUN	1	2	3	4	5	6	7	8	9	10
# 14	Ø1	3								3	3
	Ø2	3					3	3	3	3	3
	Ø4	3						3	3	3	3
	Ø5	6	3	3	3		3	3	3	3	3
	Ø6	6	3	3	3						3
	Ø8	3	3	3							
	Ø2P	2					2	2	2	2	2
	Ø4P	4	2						2	2	2
	Ø6P	4	2	2	2						2
	Ø8P	4	2	2				2	2	2	2
	Ø2PPB	1						1	1	1	1
	Ø4PPB	1								1	1
	Ø6PPB	1	1	1							
	Ø8PPB	2	1	1	1		1	1	1	1	1
	PPB Common	2	1	1	1		1	1	1	1	1
	P.E.C.										3
	Spares	6	3	3	3		3	3	3	3	
	Total # 14	51	21	19	13		13	19	21	25	35
# 10	Internally Illuminated Street Name Sign						2	2	2	2	2
	Luminaires			2			2	2	2	2	2
	Signal Common	2	1	1	1		1	1	1	1	1
	Total # 10	2	1	3	1		5	5	5	5	5
# 6	Signal Service	2									
Detector- Lead-In Cable	Ø 1 Detectors	1					1	1	1	1	1
	Ø 2 Detectors	4								4	4
	Ø 4 Detectors	2	2								
	Ø 5 Detectors	1									1
	Ø 6 Detectors	4	4	4	4						
	Ø 8 Detectors	2						2	2	2	2
	TOTAL DLC	14	6	4	4		1	3	3	7	8
CONDUIT SIZE		2-78C	78C	63C	53C	78C	53C	63C	63C	78C	78C

Table C4D-8. Available Conduit Area

SQUARE MILLIMETERS					
CONDUIT SIZE	PERCENT OF FILL				
	26%	35%	40%	50%	100%
35	145	194	220	277	555
41	340	460	526	658	1316
53	563	759	867	1084	2168
63	803	1081	1236	1545	3090
78	1237	1666	1904	2380	4761
91	1661	2235	2554	3193	6387
103	2134	2872	3282	4103	8206

As a practical limit, projects for new installations should be designed to the 26% fill limitation.

SQUARE INCHES					
CONDUIT SIZE	PERCENT OF FILL				
	26%	35%	40%	50%	100%
1"	0.23	0.30	0.35	0.43	0.86
1-1/2"	0.53	0.72	0.82	1.02	2.04
2"	0.87	1.18	1.34	1.68	3.36
2-1/2"	1.24	1.68	1.92	2.45	4.79
3"	1.92	2.58	2.96	3.69	7.38
3-1/2"	2.57	3.47	3.96	4.95	9.90
4"	3.31	4.45	5.09	6.36	12.72

As a practical limit, projects for new installations should be designed to the 26% fill limitation.

Table C4D-9. Conductor Size

METRIC UNITS			
CONDUCTOR SIZE (AWG)	TYPES TW, THW, USE, RHH & RHN		D.C. RESISTANCE Ohms/1000 m
	INSULATION THICKNESS (mm)	TOTAL AREA (Sq mm)	
#14	1.14	14	10.67
#12	1.14	16	6.33
#10	1.14	20	3.97
#8 Stranded	1.50	40	2.56
#6 Stranded	1.50	53	1.61
#4 Stranded	1.50	70	1.02
#2 Stranded	1.50	95	0.62
Type B Loop Detector Lead-in Cable (DLC)		47	
Type C Loop Detector Lead-in Cable (MLC)		42	
Magnetometer Detector Lead-in Cable (MLC)		32	
Signal Interconnect Cable (3-Pair)		60	
Signal Interconnect Cable (6-Pair)		117	

ENGLISH UNITS			
CONDUCTOR SIZE (AWG)	TYPES TW, THW, USE, RHH & RHN		D.C. RESISTANCE Ohms/1000 ft
	INSULATION THICKNESS (Inches)	TOTAL AREA (Sq Inches)	
#14	0.045	0.021	3.07
#12	0.045	0.025	1.93
#10	0.045	0.031	1.21
#8 Stranded	0.060	0.060	0.78
#6 Stranded	0.060	0.082	0.49
#4 Stranded	0.060	0.109	0.31
#2 Stranded	0.060	0.147	0.19
Type B Loop Detector Lead-in Cable (DLC)		0.073	
Type C Loop Detector Lead-in Cable (MLC)		0.064	
Magnetometer Detector Lead-in Cable (MLC)		0.049	
Signal Interconnect Cable (3-Pair)		0.091	
Signal Interconnect Cable (6-Pair)		0.181	

CHAPTER 4E. PEDESTRIAN CONTROL SIGNALS

Section 4E.01 Pedestrian Signal Heads

The following is added to this section:

Standard:

Signal design shall provide for or prohibit pedestrian movements.

Section 4E.06 Accessible Pedestrian Signals

The following is added to this section:

Option:

The installation of Audible Pedestrian Signals may be considered when an engineering study and evaluation have been conducted and the following minimum conditions have been met:

- a. The proposed intersection crosswalk must be signalized.
- b. The audible devices should be retrofittable to the existing traffic signal hardware.
- c. The signalized intersection should be equipped with pedestrian push buttons.
- c. The selected crosswalk must be suitable for the installation of audible signals, in terms of surrounding land use and traffic patterns.
- e. There must be a demonstrated need for the audible signals in the form of a request from an individual or group that would use the audible signal.
- f. The individual or group requesting the device should agree to train the visually impaired users of the audible signals.

Guidance:

If the “Cuckoo” / “Peep-Peep” walk sound is chosen, the audible devices selected should emit a “Cuckoo” walk sound for North-South direction and a “Peep-Peep” walk sound for a crosswalk in the East-West direction.

Standard:

The tone of the walk signal shall not be similar to the pushbutton locator tones.

**CHAPTER C4E. PEDESTRIAN CONTROL SIGNALS
(CALIFORNIA ONLY SECTION)**

Section C4E.01 Financing

Standard:

The cost of installing Audible Pedestrian Signals shall be shared with the local agency in the same manner as a traffic signal. See Section C4B.04.

CHAPTER 4K. FLASHING BEACONS

Section 4K.01 – General Design and Operation of Flashing Beacons

The following is added to this section:

Support:

Typical applications for flashing beacons include the following:

1. Signal Ahead
2. Stop Signs
3. Speed Limit Signs
4. Other Warning and Regulatory Signs
5. Schools
6. Fire Stations
7. Intersection Control
8. Freeway Bus Stops
9. At Intersections Where a More Visible Warning is Desired.

Typical uses include:

1. Obstructions in or immediately adjacent to the roadway.
2. Supplemental to advance warning signs.
3. At mid-block crosswalks.
4. At intersections where a warning is appropriate.

Option:

Only warning, regulatory or construction signs may be supplemented by flashing beacons.

Section 4K.02 Intersection Control Beacon

The following is added to this section:

Standard:

New installations of overhead intersection control flashing beacon shall consist of red indications for each approach.

The cost of installing an Intersection Control Beacon and intersection lighting shall be shared with the local agency in the same manner as a traffic signal.

CHAPTER C4K. FLASHING BEACONS (CALIFORNIA ONLY SECTIONS)

Section C4K.01 Intersection Control Beacon

Standard:

The cost of installing an Intersection Control Beacon and intersection lighting shall be shared with the local agency in the same manner as a traffic signal.

Section C4K.02 Warning Beacon Financing

Standard:

The cost of installing a Warning or Regulatory Sign Flashing Beacon on a State highway shall be at 100% State expense.

Section C4K.03 Signal Ahead Flashing

Option:

Yellow flashing beacons may be used with Signal Ahead (W3-3) signs in advance of:

1. An isolated traffic signal on either a conventional highway or on an expressway in a rural area.
2. The first traffic signal approaching an urban area.
3. Any traffic signal with limited approach visibility, or where approach speeds exceed 80 km/h (50 mph).

On divided highways where the median is 2.5 m (8 ft) wide, or greater, the installation may consist of:

1. Two Type 1 standards, each with a W41 sign and a 300 mm (12 in) signal face, with one standard located in the median and the other off of the right shoulder; or
2. A Type 9 cantilever flashing beacon installation with a Signal Ahead (W3-3) or SIGNAL AHEAD (W3-3a) sign and two 300 mm (12 in) signal faces as shown in the Standard Plans.

The above installation designs may result in noncompliance with the Highway Design Manual mandatory standards for horizontal clearance and shoulder width, and the advisory design standard for clear recovery zones. If such nonstandard features cannot be avoided, the designer must obtain approval in accordance with Topic 82 of the Highway Design Manual and the current instructions pertaining to exceptions from mandatory and advisory design standards.

On undivided highways or on highways where the median is less than 2.5 m (8 ft) wide, the installation may consist of a single standard located off of the right shoulder as described for use on divided highways, or it may be a Type 9 cantilever flashing beacon installation.

Support:

The cost of installing a Signal Ahead Flashing Beacon is normally included in the traffic signal project and the cost shared with the local agency.

Section C4K.04 Flashing Beacons at School Crosswalks

Option:

Flashing beacons at school crosswalks may be installed on State highways in accordance with Sections 21372 and 21373 of the California Vehicle Code.

Flashing yellow beacons may be installed to supplement standard school signing and markings for the purpose of providing advanced warning during specified times of operation when justified.

A flashing yellow beacon may be justified when ALL of the following conditions are fulfilled:

1. The uncontrolled school crossing is on the “Suggested Route to School”; and
2. At least 40 school pedestrians use the crossing during each of any two hours (not necessarily consecutive) of a normal school day; and
3. The crossing is at least 180 m (600 ft) from the nearest alternate crossing controlled by traffic signals, stop signs or crossing guards; and
4. The vehicular volume through the crossing exceeds 200 vehicles per hour in urban areas or 140 vehicles per hour in rural areas during the same hour the students are going to and from school during normal school hours; and
5. The critical approach speeds exceeds 55 km/h (35 mph) or the approach visibility is less than the stopping sight distance.

Standard:

If school authorities are to operate flashing yellow beacon, an inter-agency agreement shall be executed to assure designations of a responsible adult to operate the beacon controls and to provide accessibility for necessary equipment maintenance.

Where traffic signals and/or flashing beacons are justified only by the School Area Traffic Signal Warrant on a State highway, the installation shall be at 100% State expense. When any other warrant is met also, the cost is shared in the usual manner.

Section C4K.05 Speed Limit Sign Beacon

Guidance:

When a Speed Limit Sign Flashing Beacon is installed at the request of a local agency, or installed by the local agency under an encroachment permit the costs of installing and maintaining the beacon should be at 100% local agency expense.

Section C4K.06 Flashing Beacons for Fire Stations

Option:

Flashing beacons at fire station driveways or at intersections immediately adjacent to a fire station may be installed on State highways.

Standard:

The flashing beacon shall be used only to supplement an appropriate warning or regulatory sign. The flashing beacon shall be actuated from a non-illuminated condition by a switch at the fire station.

The costs of installing and maintaining the flashing beacon for the fire station shall be at 100% local agency or fire department expense.

Section C4K.07 Stop Sign Flashing Beacons

Support:

A Stop Sign Flashing Beacon consists of one or two signal sections with a flashing circular red indication in each section.

Standard:

The bottom of the housing of a Stop Sign Flashing Beacon shall not be less than 305 mm (12in) nor more than 610 mm (24 in) above the top of the stop sign.

The cost of installing a Stop Sign Beacon shall be shared with the local agency in the same manner as a traffic signal.

Section C4K.08 Flashing Beacons at Bus Stops on Freeway Interchanges

Option:

At locations of approved bus stops within interchange areas, a flashing beacon may be provided near the top of a lighting standard to provide a flag stop.

Standard:

The following design and operational requirements shall be met:

- 1. A push button shall be provided on the lighting standard with a sign explaining the purpose and operation. The sign shall state that if no bus has arrived within 15 minutes (or other time) after the button has been actuated it will be necessary to actuate it again.**
- 2. The flashing beacon shall consist of a 200 mm (8 in), signal section with an uncolored or white lens mounted on the lighting standard in such a position that an approaching bus driver can see it on the freeway.**
- 3. The operation of the control shall be such that the flashing beacon will operate for 15 minutes after the button has been actuated and then go out.**

The cost of installing and maintaining Flashing Beacons at Bus Stops on Freeway Interchanges shall be 100% State expense.